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THE NEW UNITED STATES INFANTRY MAGAZINE RIFLE.

THE magazine rifle recently adopted by the United States for its infantry is similar in many respects to the Krag-Jorgensen gun, with which the Danish troops are armed, but much improved and modified, and of the new pattern we give illustrations, for which and the accompanying particulars we are indebted to Engineering. For the sake of comparison the old pattern is represented by Fig. 1, while Fig. 2 shows the new rifle on the same scale. Fig. 3 is a large perspective view of the mechanism in open position. The other illustrations show the details. Fig. 4 is a section of the mechanism with the bolt open, and Fig. 5 a section of the same with the bolt closed. Fig. 6 is a plan of the receiver with the bolt removed, and of the magazine with the gate open; while Figs. 7, 8 and 9 are sections on A A of Fig. 6, showing respectively the gate open, the gate closed, and the cartridges in the magazine. Fig. 10 is a side view of the bolt, which, again, is shown in perspective on Fig. 14, while a top view of the bolt body is given on Fig. 15. Figs. 11 and 12 are cross sections of the assembled bolt. Fig. 13 shows the top and side view and a section of the striker. Fig. 16 is an interior view of the gate of the magazine, while the left hand part of Fig. 17 shows the rear, side, and top view of the sleeve, and the right hand part the top and left hand views of the extractor.

The receiver is bored to receive the bolt. Its bottom is smooth, facilitating its use as a single loader. The opening to the magazine is on the left side; the front of it being a ramp to direct the end of the cartridge into the chamber. At the forward end of the receiver is a recess, k (Figs. 4, 5, and 6), to receive the locking lug. The rib, a (Fig. 9), the ledge, b (Fig. 9), and the left wall of the receiver, d h (Fig. 4), and d (Fig. 9), guide the bolt longitudinally. The tang of the receiver has a groove, l (Fig. 6), in which the nose, n (Fig. 4), of the cocking piece moves and by which it is prevented from turning with the bolt. At the bottom of the receiver is a mortise, e f (Fig. 6), for the ejector. The bolt is a cylinder of steel bored out to receive the firing pin and mainspring, v and e (Fig. 5). On its exterior it has three projections, the locking lug, k, the guide rib, r, and the handle, h. On its underside is a groove, in which travels the rear end of the ejector. A triangular slot is cut in the rear end of the bolt under the handle; one of the sides of this triangle, f (Figs. 10 and 15), giving a warped or camming surface along which the nose, m (Fig. 10), moves when the handle is revolved, thereby cocking the hammer, and into which notch the nose falls when the trigger is pulled. A collar partly encircles the end of the bolt, and in it is the notch into which the spindle of the safety lock enters, when the bolt is locked.

The firing pin is composed of two parts, a striker (Fig. 13) and a body, connected by a ball and socket joint. On to the body screws the cocking piece, on whose lower side is the cocking cam, and on whose upper side is a notch, into which the body of the safety lock can be turned down to lock the gun. The firing pin and bolt are connected by means of a sleeve (Fig. 17). This sleeve, though a single piece, may be considered as composed of two parts. The upper part projects over the top of the rear of the bolt, and attached to it in the notch is the extractor. The lower part is a hollow cylinder which enters the rear of the bolt, and through which enters the firing pin. In the recess, w, works the collar (Fig. 15) on the bolt, connecting the sleeve and bolt, and permitting the rotation of the latter without that of the former. When the bolt is removed from the receiver it may be rotated far enough to allow it to be removed from the sleeve. The sleeve cannot be removed from the bolt while in the receiver on account of the stud, c, on the shank of the sleeve which moves in a groove, c (Figs. 4 and 11), in the bolt.

The safety lock consists of a thumb piece and a spindle, which passes in the sleeve and projects into the cavity. Half of the spindle is cut away. When the bolt is closed and cocked, the thumb piece of the spindle can be turned to the right, thereby engaging the part of the spindle not cut away in the notch in the bolt, locking the bolt, and preventing the firing pin from having any forward motion. It also prevents all motion of the bolt and handle. The mainspring is a spiral one, and, when assembled, encircles the body of the firing pin, bearing at one end against the sleeve, and at the other against the striker at v (Fig. 4).

The extractor is a long steel spring attached by a screw, o (Fig. 4), to the sleeve. On the underside of the extractor is a projection which, bearing against the guide rib, r (Fig. 10), prevents the rotation of the bolt when it is withdrawn. The front end of the extractor can, however, be lifted, and then the bolt can be revolved and withdrawn from the receiver. The extractor spring assists the extractor in retaining its hold on the cartridge.

The ejector (v q, Fig. 4, and e f, Fig. 5) lies in a mortise in the bottom of the receiver, and being pivoted at v, in rear of its center, it usually assumes the position shown in Fig. 5. The heel of the ejector in this position enters the groove in the bottom of the bolt. When the bolt is withdrawn the groove runs over the heel of the bolt, and the front end of the bolt strikes the heel, throwing up the toe, which hits and ejects the cartridge.

The magazine is a horizontal one, formed in one piece with the receiver and lying under it, merging into a detachable side piece, e (Figs. 7 and 8), which forms its curved side on the left. The opening to the magazine is on the right side, and is closed by a gate (Fig. 16), operated by a thumb piece. The gate revolves on a horizontal hinge, opening downward. On the gate is a lug which, when the gate is opened, comes in contact with the surface on the follower and retracts it from the position shown in broken lines to that shown in full lines (Fig. 6). This is necessary to allow the cartridges to be inserted in front of it. The follower is pivoted, and when the gate is closed, the spring, lying in a cut below the magazine, bears on the heel of the follower, thus tending to advance the cartridges to the position shown in Fig. 9. The magazine may be held in reserve by

Fig. 1.

Fig. 2.

Fig. 3.

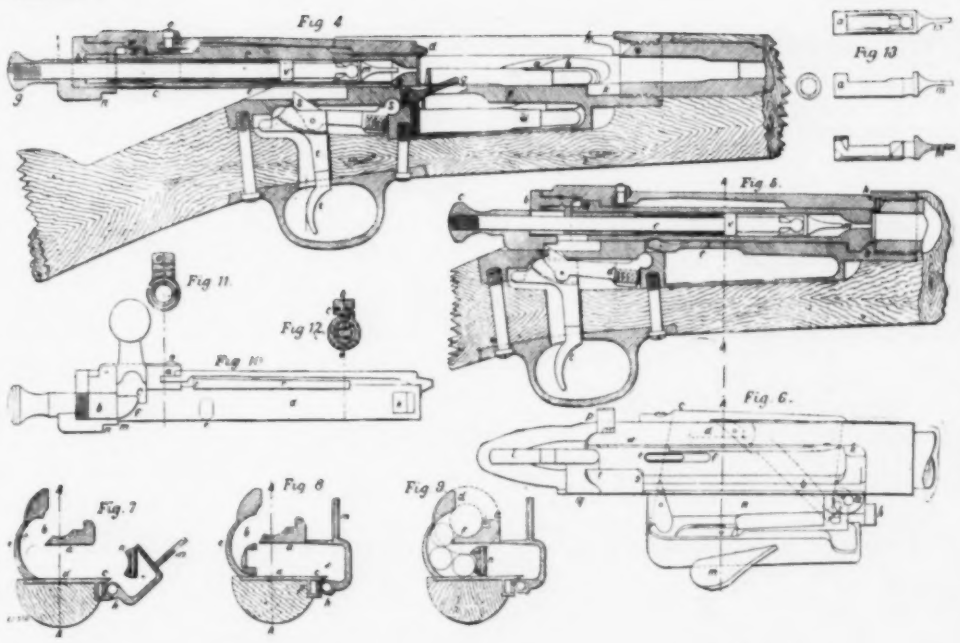


Fig. 14.

Fig. 16.

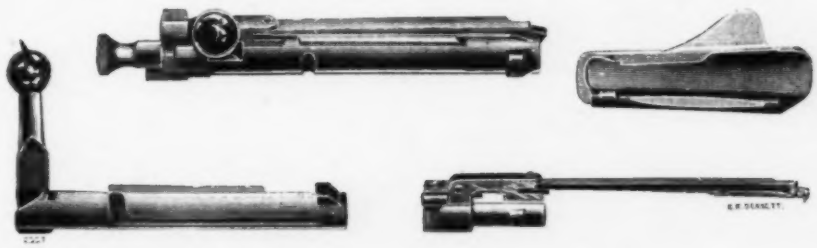


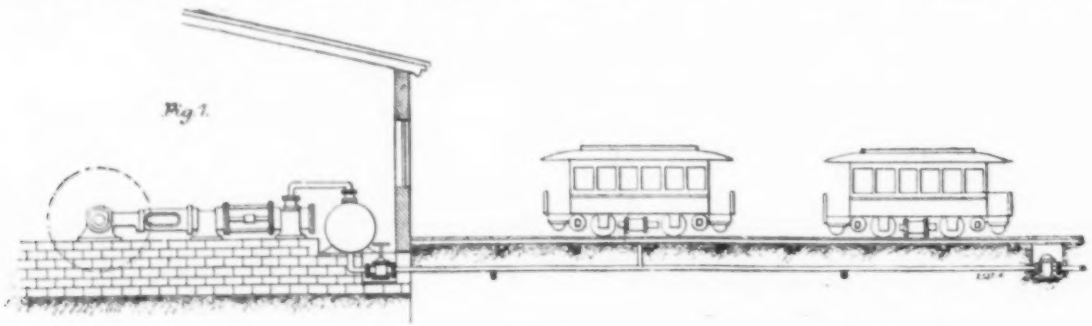
Fig. 15.

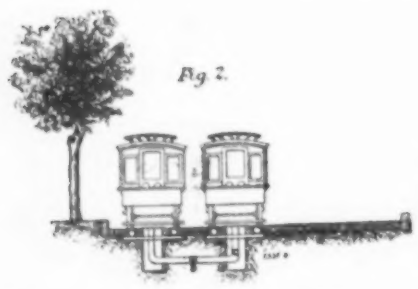
Fig. 17.

THE UNITED STATES INFANTRY MAGAZINE RIFLE.

means of a cut-off. This consists of a thumb piece and a shaft partly cut away. The portion of the shaft lies in the top of the magazine and parallel to its axis. When the magazine is in use, the plane surface of the portion lying in the top of the magazine coincides with the sides of the magazine. By turning the thumb piece 90 deg., the curved portion of a projects into the magazine, bearing down the top cartridge far enough to allow the bolt to pass forward without touching it. A spring retains the cut-off in whichever position it may be turned.

The operation is described as follows: Supposing the piece to have been fired, turn the handle to the left, thereby disengaging the locking mass, k, from its seat, in the receiver; at the same time an inclined surface at the rear of the receiver bearing against the handle forces the bolt slightly to the rear, unseating the cartridge case. During the rotation the cocking piece is forced to the rear by the inclined surface, f (Fig. 10), on the bolt bearing on the surface on the front of the cocking piece, thereby withdrawing the firing pin and cocking the piece. The bolt can now be withdrawn until the ejector strikes the empty cartridge, throwing it out. A cartridge is now placed in the receiver by hand, or if the magazine is being used, merely pushing the bolt forward, one is fed in from the magazine, and the final rotation of the bolt seats the cartridge and locks the piece for firing. In case of misfire the piece can be cocked by withdrawing the cocking piece or by rotating the bolt up and back again. If the trigger should be pulled before the bolt is entirely closed, the nose of the cocking piece striking the cam, f e (Fig. 10), will force the bolt to complete its rotation and locking before the firing pin can touch the primer. The magazine can be loaded with single cartridges or by means of a quick loader. The cut-off can be operated with the magazine full or empty, with the bolt closed or open. The whole mechanism can easily be entirely dismounted in a minute's time without the aid of any tools. In conclusion, it may be said that this piece seems to possess all the requisites now universally admitted to be necessary to a perfect magazine gun.





THE DISTRIBUTION OF COMPRESSED AIR IN PARIS.

In 1879 the first trials were made in Paris of what was afterward known as the Popp compressed air system; the earliest installation was on a very small scale, and for some years the application was limited to the operation of clocks in the streets as well as in private houses. The central station was located in a small building, in the basement of which were two compressors driven each by a 6 horse power engine. On the first floor were the pressure regulators and other controlling apparatus, and a master clock which distributed pneumatic impulses at minute intervals throughout the system of air pipes.

In a few years, however, applications to obtain compressed air as a motive force became numerous from small users of power, and the rapid increase in these demands rendered it necessary to increase the very modest installation in the Rue St. Anne. The first extension was completed in 1880, when the Rue St. Fargeau works were started on a 60 horse power basis. Anticipating rapid extension, Mr. Popp had secured a site of nearly 8 acres in the Rue St. Fargeau, and by 1887 no less than 5,000 horse power were required to compress the air consumed. We described with much detail in 1889 the condition of the industry at that time. (See Engineering, vol. xlvii., page 163, 638, 695 and 715.) Fresh extensions followed, and large additional works were completed in 1892 on the Quai de la Gare, which we have also fully described. (See Engineering, vol. li., pages 298, 327, 419, and 563.) At present the development appears to be as follows:

1. Two central stations—those of St. Fargeau and the Quai de la Gare, representing together 13,000 horse power. From these two stations there were distributed through air mains in 1892 no less than 195,000,000 of cubic meters of air (250,000,000 of cubic yards).

2. Two central time stations for the operation of pneumatic clocks throughout Paris.

3. A reseau of 104 miles of mains, of which 41 are devoted to the time service and 63 miles to the distribution of power for commercial uses; there is also a total length of the system of service pipes of 61 miles.

4. Sixteen refrigerating chambers in the basement of the Bourse du Commerce.

5. Two stations of about 1,000 horse power, used for generating electricity with compressed air motors.

6. 2,800 horse power of compressed air consumed for 90 special installations.

7. 7,400 public and private clocks.

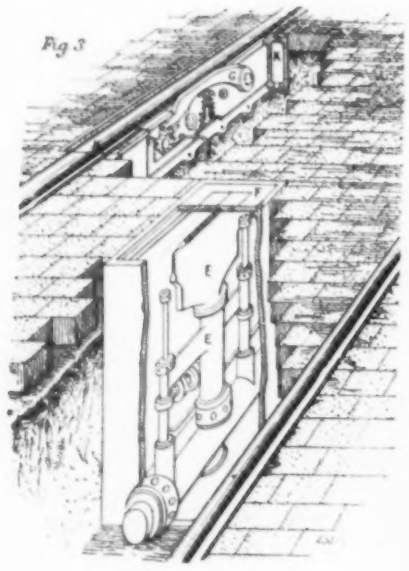
8. Three stations producing compressed air at high pressure, and representing about 1,300 horse power. These are intended for street railroad traction.

Although we fully described the power station on the Quai de la Gare more than two years ago, we may again briefly refer to it. The works were designed for a total capacity of 24,000 horse power, divided into three groups. The first section of 8,000 horse power is now at work. The air is compressed by four triple expansion Corliss engines (2,000 horse power), and steam is supplied by 20 Babcock & Wilcox boilers, divided into batteries of five. The compressors operate by stages, and have each two low pressure and one high pressure cylinder. The air is cooled during compression by spray injectors. The engines are vertical, and the compressors are driven from an overhead shaft.

The following are some particulars of the installation:

Number of sections in each boiler	12
" tubes per section	9
" " boiler	108
Length of tubes	17·8 ft.
Diameter of tubes	3·94 in.
Total heating surface of tubes per boiler	1958 sq. ft.
Diameter of steam cylinders, high pressure	33·47 in.
Diameter of steam cylinders, intermediate	55·12 "
Diameter of steam cylinders, low pressure	78·74 "
Air compressing cylinders, low pressure	43·31 "
Air compressing cylinders, high pressure	30·71 "

The boilers are registered for 170 lb., and the working pressure is about 140 lb. per square inch.



The compressors are arranged to deliver into the receivers at a pressure of 114 lb. per square inch. The quantity of air actually compressed by the four engines per hour to 114 lb. is equal to about 70,000 cubic meters, or 2,470,000 cubic feet, at atmospheric pressure. The air is compressed by each engine into two reservoirs, having a capacity of 1,000 cubic feet, whence it flows into the principal air main, which is 19·69 in. in diameter. The sizes of the mains vary from this diameter to 11·8 in.; the larger are made of wrought iron welded; the smaller are of cast iron. The secondary mains range from 7·87 in. in diameter to 1·58 in.; the service pipes are of lead, and their diameters vary from 3·15 in. to 1·58 in.

When the station on the Quai de la Gare was undertaken, the Creusot Company, who supplied the engines, guaranteed as a maximum consumption of fuel, 1·54 lb. per indicated horse power per hour. The conditions of trials as laid down in the specifications were:

Duration of each trial	6 hours.
Number of revolutions per minute	60
Boiler pressure	163 lb. per sq. in.
Effective pressure of compressed air	113 lb.
Maximum indicated horse power	2,000
Fuel	Briquettes d'Anzin

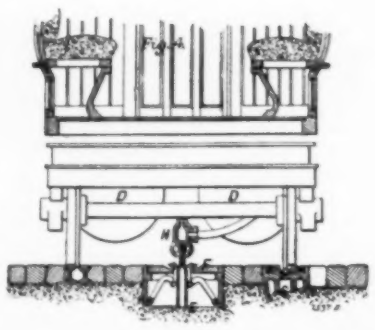
An official trial was made only on January 19, 1893, about 13 months after the engines had been in constant work. The following figures give the principal results obtained:

Average number of revolutions per minute	59·635
Average pressure of steam in boilers	163 lb.
Average pressure of steam at the admission valve of the high pressure cylinder	146 "
Average vacuum in the condenser	28·35 in.
Pressure of air in compressors, low pressure	32·7 lb.
Pressure of air in compressors, high pressure	102 "
Temperature of the air when entering the low pressure compressors	40·67 F.
Temperature of the air when leaving the high pressure compressor	69·0 "
Horse power indicated	1996·5
Net fuel consumed per horse power per hour	1·3 lb.

Two trials, at an interval of three months, were made to test the efficiency of the engines and compressors, and the results tabulated below were, it is stated, arrived at.

	Number of revolutions per minute.	Total mechanical efficiency.	Final pressure of the air.	Volume of air at atmospheric pressure compressed per hour and per horse power.	Ratio of actual to theoretical work in compressing the air.
		p. c.	lb. per sq. in.	cubic feet.	
First trial made by the engineers of the Popp Company	59	84	74·67	363	1·281
Second trial, made by Prof. Gutermuth	40	89	85·33	365	1·192

It would appear from these trials that the mean total



efficiency is 80·8 per cent. It is claimed that the actual cost of 100 cubic meters (3,530 cubic feet) of air compressed to 113 lb. per square inch is 0·4536 fr., or less than 5d. This figure was arrived at after a trial of 24 hours in the station of the Quai de la Gare, and it was confirmed by the results obtained from three months' subsequent working.

The applications of compressed air in Paris are very numerous and varied, but according to the latest information the following classification may be made:

1. Distribution of power in quantities ranging from the minute time impulses to motors of 150 horse power. It was worth noticing that in many workshops old steam engines are now worked with compressed air, the boilers serving as reservoirs in which the air is heated before admission to the cylinders.

2. Ventilating and other sanitary purposes.

3. Refrigerators, especially cold stores for the preservation of meat, etc.

At the Bourse du Commerce the installation for this purpose is large, comprising 16 cold air stores, containing together 5,300 cubic feet. Besides this, compressed air is used to drive air motors for electric lighting; the exhaust from these motors is utilized to assist in reducing the temperature of the cold stores. Another series of motors at the Bourse installation is used for heating and ventilating purposes throughout the establishment.

4. The manufacture of ice as a by-product of the compressed air used as motive power.

5. Elevating or lifting water and other liquids; this is applied chiefly to breweries, but there are large installations at the depots of Bercy and the Quai St. Bernard for lifting wines, spirits, etc.

6. Emptying cesspools (usine Retiro).

7. Passenger and luggage elevators.

8. Pneumatic clocks on the Boulevards in Paris and in about 2,000 private houses.

9. Mechanical traction on the Nogent tramways for a distance of about 8¾ miles. This application of compressed air is on the Mekarski system.

The following table gives an idea of many of the various uses to which compressed air has been put in Paris.

One of the most interesting applications of compressed air in Paris will be that for the propulsion of tramcars on the Conti system, a system in experimental use, we believe, in Vienna. Some preliminary trials have been made at Nantes and at Nogent, and the re-

INDUSTRIAL APPLICATIONS OF COMPRESSED AIR IN PARIS.

	Less than 1 horse power.	Horse power. 2 to 6	7 to 12.	13 to 25	26 to 50.	51 to 100.	101 to 150.		
Lithographic printing presses	31	25	2	1	....	....	....	....	62
Printing	6	4	....	....	4	2	....	....	14
Circular saws, etc	20	34	3	2	....	....	....	....	59
Cloth cutting machines	29	2	....	....	....	....	....	....	31
Pumps	....	2	1	....	....	....	....	....	3
Mills	19	2	....	....	....	....	....	....	21
Lathes	58	51	9	....	....	....	....	....	118
Rolling mills	10	6	....	....	....	....	....	....	16
Refrigerators	3	1	3	....	....	....	....	....	7
Coffee mills, roasters, etc	13	1	....	....	....	....	....	....	14
Cutting and drilling machinery	7	8	....	....	....	....	....	....	15
Mixing machinery	14	4	....	....	....	....	....	....	18
Sewing machines	53	7	....	....	....	....	....	....	60
Chopping machines, etc	22	7	....	....	....	....	....	....	29
Quilting "	5	1	....	....	....	....	....	....	6
Cutting "	9	1	....	....	....	....	....	....	10
Electrotyping "	2	1	....	....	....	....	....	....	3
Embroidery "	10	....	....	....	....	....	....	....	10
Shearing, etc. "	5	1	....	....	....	....	....	....	6
Turbines and ventilators	6	11	....	....	....	....	....	....	17
Machines for carding and rolling	5	5	....	....	....	....	....	....	10
Comb factory	....	....	....	1	....	....	....	....	1
Dynamos	6	6	1	1	2	....	....	....	16
Machines for surgical and dental purposes	4	2	....	....	....	....	....	....	6
Soda water factory	....	1	....	....	....	....	....	....	1
Provision merchants	3	1	....	....	....	....	....	....	4
Woodworking machinery	2	6	....	....	....	....	....	....	8
Cutting and polishing machinery	2	....	....	....	....	....	....	....	2
Envelope machinery	3	1	....	....	....	....	....	....	4
Boot machines	1	2	....	....	....	....	....	....	3
Motors	....	....	2	2	....	....	....	....	4
Motors for ventilating under-stations	33	....	....	....	....	....	....	....	33
Motors for dynamos and cold stores	1	10	9	10	1	10	1	1	43
Lifting beer and wine	22	....	....	....	....	....	....	....	22
Elevators, luggage elevators	....	6	4	10	....	....	....	....	20
Blowpipes	96	....	....	....	....	....	....	....	96
Lace and trimming makers	4	....	....	....	....	....	....	....	4
Silk weaving	2	....	....	....	....	....	....	....	2
	509	209	34	27	5	12	1	1	798

sults obtained were sufficiently good to justify the Compagnie Generale des Omnibus to construct three new lines in Paris, which will be opened for traffic during the present year. In the Conti system the air is compressed at a relatively high pressure at a central station; it is then admitted into the mains, B, placed beneath the rails (see diagram, Figs. 1 and 2, on previous page).

Branches, C, lead the air nearly to the surface into automatic devices by which the car reservoirs can be charged. By this arrangement it is considered that one central station will be sufficient, whatever the length of the line may be; and as the charging devices can be introduced at short intervals, the dead weight of reservoirs to be carried is relatively small. The distance between the charging stations varies according to circumstances, but for convenience they should be located at the recognized stopping places. Fig. 3 is a diagram that gives some idea of the arrangement. An iron box is sunk into the roadway to inclose the mechanism; this box is covered in by a plate containing two hinged flaps, F, placed immediately over the air nozzle, E. This nozzle is the continuation of a plunger working in the cylinder, E^1, which can be placed in connection with the air main. As the front truck of the car passes over the rails it strikes the lever, G, and depressing it, opens a valve that admits air beneath the plunger, E, raises it, and causes the air nozzle to push open the flaps, F, and rise above the level of the road. By the time it has reached its full height the nozzle engages in a connection, H, communicating with the reservoirs, D, placed on the car; a valve is opened that admits the compressed air through the nozzle into the reservoirs, which are filled in a few seconds. The valve is then closed, and as the car proceeds the lever, G, is released, the air beneath the plungers in the cylinder, E, escapes and the nozzle falls, the flaps, F, closing over it and restoring the street surface. In the event of the mechanism becoming deranged, air stand pipes are provided, so that the reservoirs can be charged by coupling up.

The results obtained will be watched with considerable interest, so soon as the system passes out of its experimental stage, which it promises to do shortly under the care of the Compagnie Generale des Omnibus.—Engineering.

THE CHILEAN CRUISER BLANCO ENCALADA.

WE give an illustration of the powerful Chilean cruiser Blanco Encalada, built at the Elswick shipyard of Messrs. Sir W. G. Armstrong, Mitchell & Co. Her principal dimensions are as follows: Length, 370 ft.; breadth, 46 ft. 6 in.; mean draught, 18 ft 6 in., and her displacement is 4,500 tons. We are indebted for these particulars and for our illustration to the Engineer, London. The engraving is from a photograph taken during the gunnery trials of the vessel.

The armament of the vessel consists of two 8 in. breech-loading guns, two 6 in. quick-firing guns, twelve 3-pounder quick-firing guns, twelve 1-pounder guns, two Gatling guns, and five torpedo tubes. At the trials all of these guns and torpedo tubes were discharged in various directions, and the guns at extreme elevation and depression, in order to test the structure of the ship, with the result that all the fittings and other parts were shown to be of ample strength and able to stand all the strains to which they might be subject by the firing of the guns in action. The steam trials showed that the vessel could run with forced draught at a speed of 22·78 knots, and that she could run as long as her coal supply lasted, with natural draught, at a speed of 21·75 knots. Her normal supply of coal is 350 tons, but she can carry 900 tons. With her bunkers full, the above speeds would be somewhat reduced; but starting with her full coal supply she could steam at, say, the mean speed, 21½ knots, for eighty-four hours, and would cover a distance of 1,800 knots, while at the economical speed of 12 knots she could steam for twenty-eight days, and cover a distance of 8,000 knots.

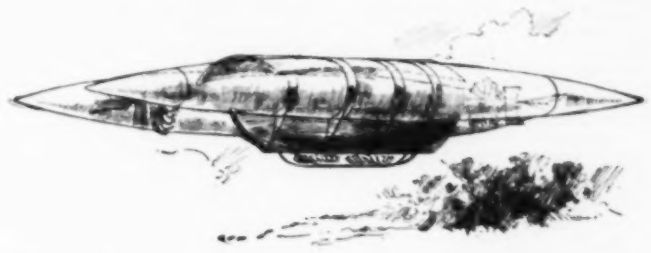
The vessel is sheathed with wood and coppered. She has an inner bottom throughout. She carries the very powerful armament above enumerated. She is one of the fastest cruisers afloat, and these splendid results have been obtained on a displacement of only 4,500 tons.

The engines and boilers are by Messrs. Humphrys, of Deptford.

SPECIFICATIONS FOR A PROPOSED CATAMARAN AIR SHIP FOR UNITED STATES COAST DEFENSE.

Invented by J. FRANKLIN CAMERON, Brooklyn, N. Y., U. S. A.

AT an outlay not exceeding the cost to build, equip and ordnance one cruiser, the United States government could build and equip a large fleet of air ships as described hereinafter, and station them at various points along our coasts. Their cost for maintenance would be only nominal.



These ships would be able to locate and destroy by overhead attack, at one hundred miles seaward, all the navies of the world.

FORM AND DIMENSIONS.

Spindle shaped twin hulls, length tip to tip	400 ft.
Diameter of largest section	50 ft.
Distance between hulls, 25 feet, plus the tapering, making the outside breadth of ship 50+50+25	125 ft.
Capacity of each hull, 418,800 cubic feet; total cubic feet	837,600

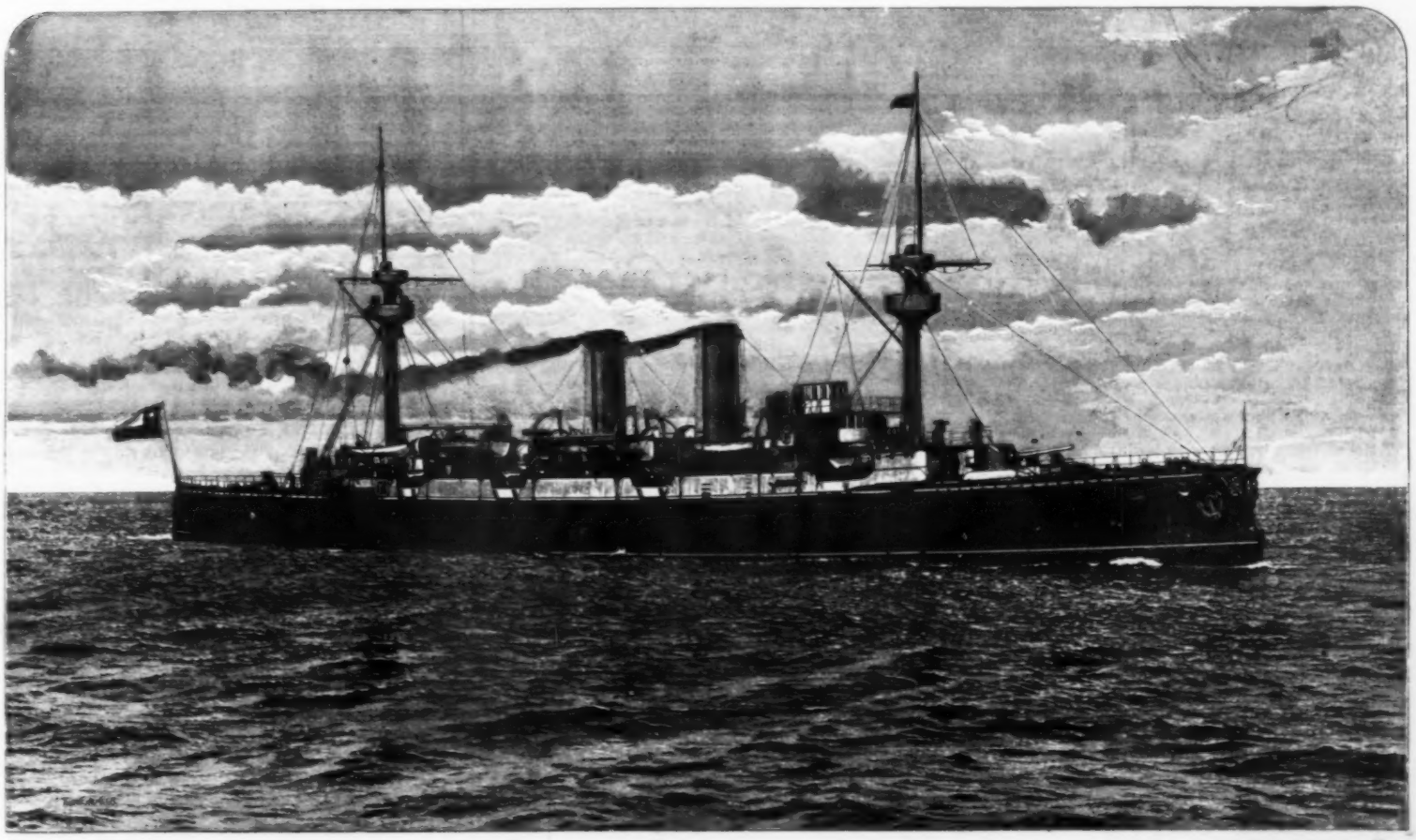
VERTICAL LIFT.

Contents of hydrogen gas, buoyancy power based on Renard and Krebs war balloon La France	56,000 lb.
Equipped with two engines, each 300 H. P., applied to two vertical propellers. Estimated lift, 22½ pounds per H. P.	13,500 lb.
Total	69,500 lb.

It has been shown by experiments made by Prof. Langley, Dr. Freninges and others, that there can be a much greater lift per H. P. than that given in this estimate. Vertical upward movement may be made at such slow speed that air resistance need not be considered.

DEDUCT

Weight of twin hulls, cloth covered, based on 1·23 pounds to 100 cubic feet capacity, the same as La France, and greater than estimated by Carl E. Myers, aeronautical engineer and manufacturer of hydrogen-tight balloons	10,300 lb.



THE CHILEAN WAR SHIP BLANCO ENCALADA.

Weight of . . . sheets of light cloth, impervious to gas, and stretched vertically, at intervals within the hulls, to prevent surging of gas from end to end of hulls	200 lb.
Weight of nickel steel frames inclosing the hulls from tip to tip, and to which the hulls are tied to keep them in place, and to prevent backward sagging from head pressure	4,800 lb.
The frames to be constructed of beveled edge rings welded on their outside, in longitudinal form, to tubing, with the greater number both of rings and tubes on the middle section, and of sufficient strength to support the boat and its equipment as described hereinafter.	
Weight of tubes connecting the hulls to equalize the gas between them, and for a middle coupling	500 lb.
Weight of a tubular slatted arched roof, tubular joints and elbows; slats of aluminum in sectional lengths to open, as a Venetian blind, fore and aft. Total of lengths, 100 feet, supported on arched girders of steel	4,000 lb.
This arched roof to cover the upper middle section of the space between the inner faces of the hulls, one-fourth their length. Estimated carrying power about 5,000 pounds, not allotted in these specifications. There are other very important purposes for this arched roof, such as for general stability and safety, and, adopting the valuable suggestion of Hiram Maxim, it can be utilized excellently as a steam condenser.	
Weight of boat, spindle shaped and keeled, length, 120 feet; diameter of largest section, 20 feet, and with duplex compartments at its ends to hold condensed hydrogen gas to replace any escape of it from the hulls	4,000 lb.
This weight is comprised principally of a cradle and braces by which the boat is suspended to the hull frames, in a cradle formed by jointed braces welded to the lower outer quarter section of each frame, and joined to perpendicular braces from the inner faces of the frames, and such other bracing of boat to frames as may be necessary, and by which the boat may swing on a level keel.	
Weight of two engines of 300 H. P. each, at 15 pounds per H. P. including boilers, platforms and frames	9,000 lb.
The engines and boilers of steam yacht Norwood weigh 19 pounds per H. P. It is estimated by John P. Holland, an expert naval engineer, that by substituting oil for coal, this weight could be reduced from 19 pounds to 15 pounds per H. P. There are working engines of even less weight, such as Mr. Hargrave's of 10·7, and Mr. Maxim's of 8 pounds per H. P.	
In addition to the usual advantages of two engines instead of one, it would seem to be better to locate them toward each end of the boat, as far apart as practical. This would prevent tilting of the ship in gusts of wind, and would spare amidships for fluctuating and movable weight, such as her crew and supplies.	
Weight of two horizontal rudders and fixtures, to be located between the hulls at their extremities, and to be angled up and down to give similar direction to the hulls	900 lb.
Weight of two vertical rudders and fixtures to give lateral direction	400 lb.
Weight of two vertical propellers, located on a longitudinal line beneath the boat	1,500 lb.
Weight of two horizontal propellers, 25 feet diameter, one fore, one aft, located at intersecting points of greatest head resistance. Estimated speed, 400 revolutions per minute	1,500 lb.
Weight of two vertical and two horizontal shafts	1,700 lb.
The propellers to be skeleton frames with transverse metal plates, and the shafts to be six steel rods, one inch in diameter, planted in steel disks at intervals.	
Weight of tanks for oil and water	1,500 lb.
Weight of crew of eight men and provisions	1,000 lb.
Weight of dynamite bombs	2,000 lb.
Weight of duplicate sets of tubular rockers, located under the vertical propellers to protect them	800 lb.
One set of rockers under each propeller, with a drop of 10 feet. On these rockers the ship can anchor with her keel at an elevation of 12·6 feet above ground.	
Total weight of hulls, frames, rigging, machinery, crew, provisions and ammunition	44,700 lb.
Weight of oil fuel for engines, estimate of John P. Holland, one pound per H. P. an hour, 20 hours × 600 pounds	12,000 lb.
Weight of water supply for boilers, 20 pounds per H. P. an hour, equal to 1200 pounds for 600 H. P. Five per cent. an hour loss in condensing; total loss, 600 pounds an hour × 20 hours	12,000 lb.
	68,700 lb.

It is practical to reduce loss in condensing below an appreciable point, then, one-half the weight allotted to water could be added to fuel, and thereby gain several more hours' propulsion. Drifting with favorable winds is not taken into consideration.

It is apparent that the engines, when running at full speed, would lighten the ship 600 pounds an hour in fuel consumption, and when the consumption of fuel and water has equaled the actual vertical lift of the propellers, the equilibrium of the ship would be at the sea level, with an upward tendency. It would then become a matter of judgment with the navigator to elevate his course, or to angle the forward horizontal rudder downward to keep the same elevation, and, when desired, open the slatted roof and work the vertical propellers to effect an easy landing.

Necessary safety valves are not designated in the plan, but are understood to be a part of it.

The only unsolved problems relating to the navigation of an aerial ship as described herein are:

First—With two vertical propellers, each of 300 H. P., how much may be their lifting power in excess of 13,500 pounds, as estimated?

Second—With two horizontal propellers of 25 feet diameter, and the 600 H. P. applied to forward locomotion, how much may be the normal speed of the ship?

With hulls of same form and dimensions as herein given, and with 400 H. P. in place of 600 H. P., Octave Chanute, C.E., an authority on aeronautics, has estimated a possible speed of 35 miles an hour.

Third—Admitting the estimates and claim in these specifications, what then would be the result after a few years of improvements?

Carl E. Myers, an expert balloonist, who has, more than any other person, a practical knowledge in recent ballooning, writes in reference to this plan and its detail and purposes, under date of July 31, 1894: "I have investigated it as fully as my time has permitted, and think it entirely practical of accomplishment in expert hands, and competent to do the work designed." In one of Mr. Myers' papers he says that, from an elevation of 1,500 feet he has hit and killed a duck upon the water by dropping shot from his hand, after two or three preliminary trials for position. From this it would appear to be not difficult to drop dynamite bombs on a ship or within a fort directly below.

Aerial navigation seems to be strictly a governmental affair, and not applicable to commerce or to ordinary travel. This plan describes solely an offensive and defensive war aerostat, against which cities, fortifications and navies, within its radius of flight, would be defenseless. Nothing would be left for the science of war but open sea and open field slaughter; perhaps then war would be abolished.

The second step would be the circumnavigation of the earth via both the equator and the poles.

J. Franklin Cameron.

23 Seventh Avenue, Brooklyn, N. Y.

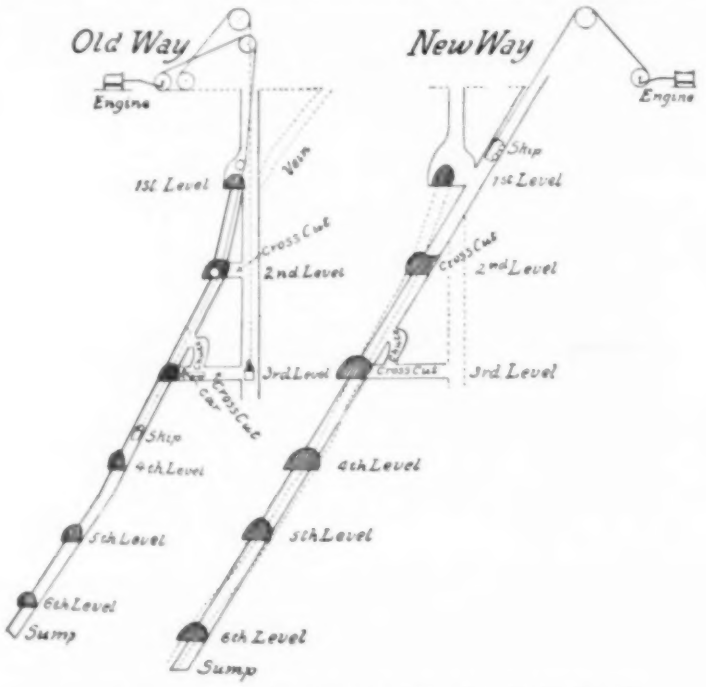


Fig. 10.—THE OLD AND NEW METHODS OF SHAFTING.

[From the Colliery Engineer.]

A TYPICAL GOLD MINE.*

By Prof. Arthur Lakes, of Golden, Col.

INCLINE SHAFT AND LOWER LEVELS.

Returning to the surface, we descended by the main incline shaft to the sixth level, the lowest in the mine. (See plan of workings in October 13 issue.)

The incline shaft is driven down on the natural dip of the vein and in the vein, whose inclination is 68 degrees from the horizontal.

The incline system of shafting on a vein is the best system in medium size dipping veins when the incline shaft is wholly in the vein and occupies its whole width, together with, if need be, part of the wall work as well. But in a very wide vein, particularly if it is all pretty rich, the vertical shaft is preferable, especially, too, when a great amount of haulage quickly to the surface is required.

If need be, the shaft may be located wholly outside the vein in the country rock, both in inclined small veins and vertical large veins, running close to and parallel with the vein and reaching the vein by short cuts. This is more especially advisable when the vein in question is very valuable throughout its entire thickness.

In the Bassick is an example of a wide vertical vein at Silver Cliff, Col. The shaft having been put down vertically in the center of this very valuable vein when all the valuable material was worked away around it, there was little left to support the shaft but its own woodwork. It would in this case have been better to have put down a vertical shaft wholly outside of the vein, and have reached and won the ore deposit by short cross-cuts from it. If an incline is put down on a wide sloping vein, it should lie directly on the foot-wall, as in the present instance. On the other hand, the disadvantage of a vertical shaft cutting a dipping vein is, that when great depth is attained, such long and expensive cross-cuts have to be made through dead work to reach the vein.

This was the case in the present instance. The original owners were old Comstock miners. This mine was developed by the vertical shaft and cross-cut system, and so they applied the same system to this vein, but at 500 or 600 feet depth the expense of 100 foot cross-cuts was very great; so a compromise was attempted between an incline and a vertical shaft, as shown in Fig. 10. This involved some two or three times handling of the ore, and by this system a loaded skip took about half an hour coming up to the surface from the bottom level.

The present manager concluded to abandon the old shaft and reopen the mine by the present incline, following the dip of the vein. Now the loaded skip comes up to the surface in less than a minute.

The friction on the machinery wheels, etc., of an incline is, of course, greater than on a vertical shaft, but expense, time, and labor are saved, and ore is being taken out all the time, instead of a perpetual system of dead work.

As we descended we passed the openings of various levels with platforms and chutes for loading onto the skip.

At the bottom of this incline shaft is the sump, a tank for mine water 25 ft. square. A continuous stream of rusty mineralized water pours down the side of the incline, receiving contributions from the outlets of the different levels, whose floors incline gently at a grade of 10 in. in 100 ft. toward the shaft on either side. The water drains from them by a gutter on the side of the rail track. This fissure vein, as in many cases, is the natural course of a spring. The water that pours down it is not mere seepage surface water, but a living spring in the vein itself.

At the foot of the incline, close to the sump, is a large Worthington pump for pumping up water from the sump through a bronze pipe, composed of brass, tin, and alumina. This pipe is about 5 in. in diameter, and cost $4 per foot, and, with putting it down, $5,000. This expensive pipe was found necessary, as iron pipes were so rapidly eaten up by sulphuric acid, sulphate of copper, vitriol, and other metallic acids of the ore.

In this sixth, or bottom level, along the foot wall, modern deposits of green sulphate of copper and red oxide of iron and other metalliferous minerals combined with solutions of lime and silica were seen laying the foundation of a future and modern vein.

In these damp levels the destruction of ironwork is extraordinarily rapid, and the expense of replacing iron pipes carrying air to the drills, etc., is great. These pipes have to be propped up above the wet ground. An iron shovel left only a day in these acid waters is ruined, and I saw large sheets of iron that you could cut like cheese.

Such mine water, it is obvious, could not be used to feed boilers for steam purposes.

In the third level, at a point directly under the bed of the river, there is a good deal of moisture, as well as a large ore body, and the deposition of iron oxide and copper sulphate in belts and streaks was very marked.

In this third level the dike of porphyry we have alluded to makes a sudden bend, and leaving the hanging wall, cuts directly across the vein, slightly faulting it. The vein matter does not pass through it.

In part of the third level toward the south, which is neither very dry nor wet, but dampish, are great quantities of a white fungus, adhering to the old stulls or woodwork, which have a rotting tendency, like dry rot. It hangs down in festoons like white rags, or even coats the side of the mine with a white crust; it burns, when a candle is applied to it, with a disagreeable smell.

This fungus is a fertile source of decay in old workings that are somewhat dry; on the other hand, timbers in the wet drifts saturated with mineral water are almost imperishable. These timbers are so water

* Continued from Supplement No. 980, page 15662.

logged and saturated with metalliferous solutions, that they may be considered in a sense fossilized. I am told that an ax will hardly touch them, and doubtless if they were burned, something like a cast or replacement of the original fibers of the log would be found preserved in a metallic state. In the third level was an instructive example of faulty timbering, and of the importance of putting in timbers just right from the start. The stulls here, as in the other levels, are exposed to enormous lateral pressure from the hanging wall and are cracked, split and crushed; but unlike the newer timbering, we observed these stulls to be frequently out of place, bent inward, and in consequence that they had been propped up in all sorts of ways by the recent management to keep the level

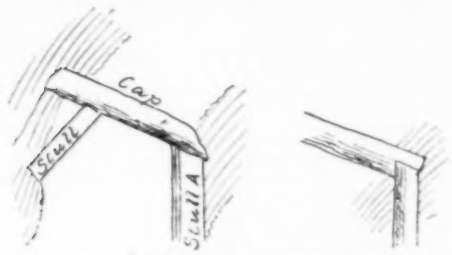


FIG. 11.—METHODS OF TIMBERING.

open. This was partly owing to the decay and age of the old stulls, but mainly owing to their not having been properly laid. The slope they preserved to begin with was too flat, and the butt ends, instead of being fitted into hitches, lay against the bare wall or rested on upright props, and their line of juncture with these props was so fixed that they would easily slide when pressure was applied. See Fig. 11. Large pockets of ore had been opened in big caves toward the end of this level.

To the north this level passes under the bed of the creek, yet strange to say but little water seems to seep down from this source. In excavations in the bed of the creek, they found that an impervious layer of clay lined its bottom. A large chute or body of ore occurs,

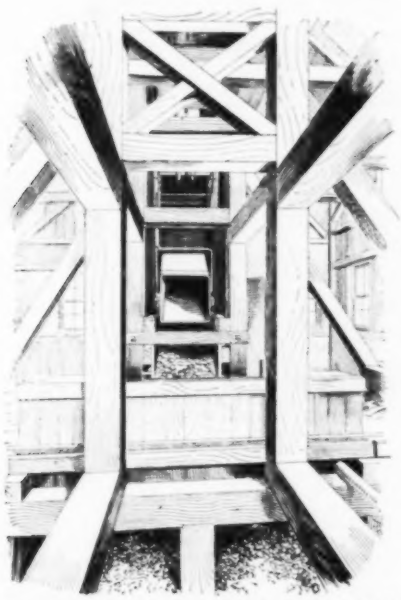


FIG. 12.—DUMPING ORE INTO THE SORTING ROOM.

however, beneath the creek. Further on the level passes beneath the crest of the mountain and another ravine on the surface.

Near the end of the level we climbed up by a rope ladder about 70 feet into a stope. Here we found a good example of a contact vein (Fig. 2) between porphyry and gneiss. Here the usual line occupied by the mineralized breccia gangue was filled by a solid mass of barren porphyry, beneath which, between the porphyry and the granitic footwall, lay the usual layer of rich smelting ore, composed of solid pyrites and bornite or purple copper, constituting a true "contact" vein between prophyry and granite. The ore below water level, that is, below the level of the creek, loses

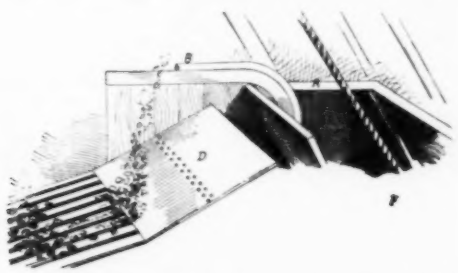


FIG. 13.—DUMPING ARRANGEMENT ON PLATFORM HEAD OF SORTING ROOM.

all its decomposed oxidized character and becomes solid unoxidized ore.

ORE SORTING.

Emerging from the mine, we visited the ore sorting room. This room, 50 by 25 feet, occupies the upper story of a tall building; in the lower part are the bins and ore chutes, into which the sorted ore and refuse are thrown. The former is either wheeled to the mill for crushing, stamping and concentrating or passes directly through chutes into the railway car, to be shipped to Denver for smelting. The mouth, or top of the incline shaft comes directly up into this ore sorting room, at the back end, and dumps its cargo of ore through a screen called a "grizzly" on to the plates and bench of the ore sorters, and its useless rock into a bin connected with the outside, where it is trammed off in a car to the dump.

The sorting room is lofty, and an open little house or skylight on the roof receives the wheel and top of the incline shaft. The position of the shaft scaffolding is seen in our sketch (Fig. 12) rising above a platform, standing about 10 feet above the ore sorting floor beneath. Material from the mine below is drawn up by the rope to the point, A, where the skip runs out on a horizontal rail, and automatically dumps its load (Fig. 13) onto the deflector, B. This deflector or apron is a plate of iron, swinging in a sloping direction on a pivot, so that it can be reversed as needed. Thus when the

FIG. 14.—ON THE FLOOR OF THE SORTING ROOM.

skip brings up a load of ore it falls on the apron and passes over the screen, or grizzly, D, its larger pieces falling onto the sorters' table, E, on the floor of the room, and its finer stuff passing through the grizzly into a bin or chute below for immediate transfer to the mill. If again the skip brings up only dead rock, the apron is reversed and the rocks are discharged down the open space, F, to be carted to the dump, so no time is lost.

As the mass or blocks of ore bearing rock pile up on their table, the ore sorters, two or three men, select pieces, and break them up with hammers, distinguishing by long practice the different values.

The material divides itself into three or four grades.

1. Useless rock barren of ore.
2. Concentrating or middle class ore.
3. First class rich smelting ore.

The concentrating material is shoveled without much sorting into a mill hole, one of three in the floor, in a somewhat wholesale manner, as this class of ore preponderates, but from it is selected the first class ore. This is put carefully into wheelbarrows, wheeled to a scale at the further end of the room, weighed up to 400 lb. and dumped down a separate chute.

Often pieces of ore will contain half poor scattery, concentrating ore, and rich smelting ore in the same piece. The sorter with his hammer breaks off the good from the medium, and throws the latter into the mill hole for concentrating matter.

Besides this, is an intermediate class of large blocks, containing dead rock, and some ore, which are piled up in heaps on either side of the room, and are called "cobbing" ore, which the sorter cobs with his hammer at his leisure, extracting the good ore and throwing the barren rock down the rock chute. The sorters have each a box beside them, in which to put very valuable ore, prior to its being wheeled away. An ore sorter requires to be one who by long habit has become acquainted with the surface look of ores of the mine, and can tell at a glance pretty nearly whether it is to be classed as first or second class ore.

In some mines, as in the present one, where the distinction of the ores is very marked, ore sorting is not difficult, but in others where the values are very much obscured, it takes an old hand to discern between good, bad and indifferent, and even the oldest hand is liable at times to throw aside a valuable piece of ore. However, the latter, unless thrown among dead rock, is not wholly lost, if it finds its place among the lower grade concentrating ore, because it only goes to further enrich the concentrates above their average.

Through the mill holes the ores drop into the chute bins, and pile up there, until the railway car comes along, at the bottom of the building. And then a series of iron doors called ore chutes are opened by a bar and the ore pours into the box car ready to receive it. Fig. 15 shows the method of opening and shutting the ore chutes.

(To be continued.)

WEARING AWAY OF METAL PLATES BY THE ACTION OF STEAM JETS.

By J. WALTER. Chem. Ind., 16, 170-171.

THE author was led to the consideration of this subject by the behavior of a steam jacketed copper boiling pan. The copper pan was originally 8 mm. thick, and the steam entered the jacket at its lowest point. Being rather too small, the copper pan, after it had been at work some years, was replaced by a rather deeper one, but one which in all other respects was exactly similar to the original pan. After the second pan had been in use for about a year, a hole was blown through the bottom, opposite the steam inlet to the jacket.

Believing that the mishap was due to the metal having been worked down too thin at this point, a third pan was made, slightly thicker—12 mm.—which was carefully measured all over, before putting into use.

To avoid a second accident the pan was tested from time to time, and after about 14 months' work it was found that the bottom had been reduced to the thickness of paper.

This time the author attributed the wear to the hydrochloric acid used for cleaning out the pan. He had previously noticed the "pitting" produced on iron plates by the action of steam jets, and, although he could not in this case trace the wear to the steam jet, he placed the steam inlet at the side, as a precaution. Some 11 months later he was convinced that the wear was due to the steam jet, as he found the pan again worn away; not at the bottom, but opposite the jet. The reason the original pan lasted so much longer is due, the author thinks, to its being

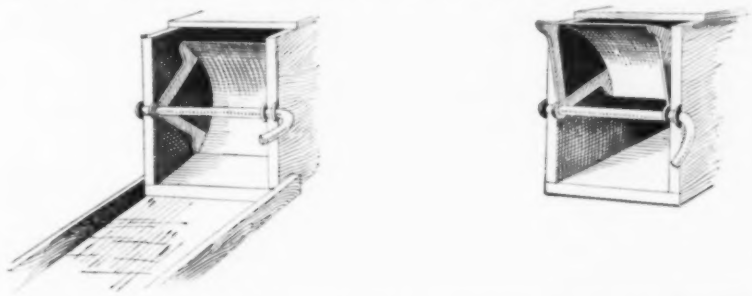


FIG. 15.—METHOD OF OPENING AND SHUTTING THE ORE CHUTES.

shallower than the others, and, therefore, not so near to the steam inlet and not subjected to such intense action. The author mentions a similar case that occurred with a lead-lined vessel which was heated by blowing in steam from pipes perforated with rows of holes on each side, fastened to the bottom of the vessel by lead straps. From the stirring of the contents of the vessel one pipe got twisted, whereby the row of holes on one side pointed downward. Very shortly the steam jets issuing from them pierced a row of holes through the lead bottom.

It is pointed out that the action of a steam jet is similar to that of a sand blast. In the former the abrading particles, instead of being sharp grains, are minute particles of water and rust, etc., from the pipes. Besides the purely mechanical abrasion, there is also chemical action. The steam carries with it air, which oxidizes the freshly exposed surface, and the oxide film thus formed is more readily removed than the metal itself. The appearance of holes produced

by the impinging of steam jets on to copper and cast iron plates is described, and the author concludes by pointing out that once the cause of such wearing away is recognized, its prevention becomes easy.

This prevention can be effected by placing over the point of impact thick metal disks about 300 mm. diameter; by making the direction in which the steam enters parallel to, instead of across, the jacket space; or by placing a thimble closed at the top and perforated at the sides, over the steam inlet.

A FARINA FACTORY.

"What may that be?" was my question to a passer by, and I pointed to the tall chimney of a factory which nestled on the hillside.

"Oh, that's a tatie mill," was the response.

I was in Scotland, near the village of Guay, on the Highland Railway, and the sound of shooting on the moors was evidence that grouse were still about. "Tatie" is Scotch for potato, and "mill" is universally used north of the Tweed for "factory." The reply carried me no further, but, ashamed to display ignorance, I determined to personally investigate the matter, which circumstance soon enabled me to understand that the "tatie mill" consumed potatoes, and turned out starch or farina.

A courteous foreman was my guide through the factory. There was a lot of money in farina twenty years

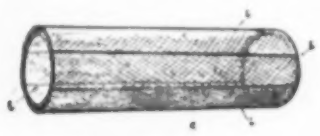


Fig. 1.

ago or thereabout, but German farina has shut up many a small factory in this country since the Franco-Prussian war. German farina was known and used here before that, but it had not the hold upon our markets it has now. The German stuff is cheaper than the British. I do not say that it is produced cheaper—I should rather put it the other way, for on our Highland farms potatoes can be grown as cheaply as in Germany, while adult male labor can be got at 12s. to 15s. a week, and water power for nothing. When Britain used British farina only, the manufacturers made fortunes quickly, and I fancy that it was their desire to hold on to this condition of things that gave the German manufacturers the chance of slipping in. It probably is true in this, as in other cases where the British "cost of production" is unfavorably compared with German, that the manufacturer's income is reckoned in the cost.

A mountain stream serves to drive the 15 foot wheel which does the chief work in the factory which I inspected. The wheel revolves slowly in sympathy with the energy of the neighborhood. Within the four walls are all the arrangements for crushing the tubers, sifting, washing, bleaching, drying and grinding. The potatoes are crushed and sifted three times, and each time starch granules are collected. There is little of special importance to note until the sifting stage is reached, and this is an ingenious method of filtration which it might be possible to adopt in some pharmaceutical processes. As the potatoes are crushed they are supplied with abundance of water, which carries off the finer material, the outgoing stream resembling nothing so closely as brown muddy water. In this condition it rushes to a filtering box, Fig. 2, in

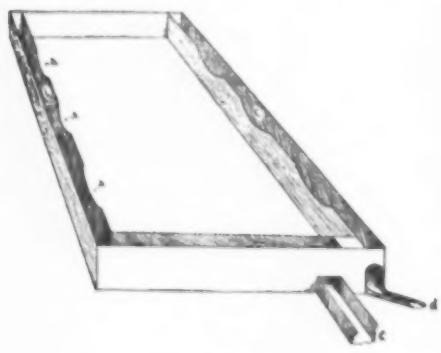


Fig. 2.

which are a number of hexagonal filtering frames, Fig. 1, the form of which is represented in the sketch. These are so arranged in the box that the stream of unfiltered material flows past and into the left ends. Each "sieve" is made up of six strong wood supports secured to the wheel ends, and round the circumference very fine muslin is stretched. Through this filtering medium the water and the finest of the starch granules pass with amazing rapidity, and the mixture is at once conveyed to long settling tanks, whence the water is drained off from time to time, and fresh wash water supplied if need be. The coarser material is reground twice, and the final coarse product, already freed by the previous washings from fiber and earthy matter, is carried to large settling ponds outside. To this I shall return later. There is nothing particular about the settling tanks. They are huge wooden boxes about 10 feet long by 2 feet wide and 3 feet deep, arranged side by side to the number of a dozen or so. The starchy mixture in these varies in color from a whity brown to pale brown. After several wash waters, this magma is lifted into the bleaching vats, which are circular, about 6 feet deep and 12 feet in diameter. Here the starch is treated with bleaching liquor, the mixture being well agitated by a mechanical stirrer—two slabs of wood attached to an iron upright with a beveled cog wheel at the top. When the proper degree of whiteness is attained the mixture is allowed to settle, and the liquor is drained off. The starch forms a solid but brittle mass, about a foot thick. It looks almost white and has a faint odor of the bleach. It has yet to be washed with several waters, one of which is made slightly acid with aquafortis—to "kill" the bleach, I presume—then it is drained and carried to the drying loft. There is nothing novel about the drying arrangements. A long range of perforated and movable shelves or trays stands in the center of the loft, and under each shelf is a steam pipe. Canvas boards are put up in front of the shelves, but quite loosely, so that the vapor has free way to escape. The drying of starch is a "kittle" thing—indeed, the risk of tumefaction has before now troubled the learned heads of the chemical side of Burlington House—but I could awake no terrors thereanent in the staid individual who guided me on this occasion. It is part of his business to dry starch, and it seems to trouble him no more than the eating of his porridge.

After the starch is dried it goes through a runner mill, and thus becomes marketable farina. On the day of my visit the drying trays were filled with a brown granular substance which reminded me of badly made ferri carb. sacch. eff. This was the coarse refuse which I have mentioned previously. When ground it goes to paper makers, who prefer it to starch for sizing. During the Franco-Prussian war this material was selling at £25 to £30 per ton. Potatoes can be bought at 24s. per ton just now.

This coarse stuff is of a dextrinous nature, and I have heard of some druggists to whom its origin is as mysterious as how the apple gets into a dumpling. I may be betraying a valuable trade secret in thus telling what I have seen. If it be so, what, I wonder, is the peculiarity of this brown refuse which makes it preferable to pure starch? It contains, I should add, all the diseased parts of the potatoes, and the coarse grains of starch, but very little fiber.—Chemist and Druggist.

THE GAS FIELDS OF INDIANA.*

By E. T. J. Jordan.

The history of the natural gas fields shows that they are of only temporary duration. Indeed, it is only natural that the accumulations of centuries should be exhausted in time by the constant and immense drains to which all the fields have been subjected. Nature cannot manufacture it as fast as it is being consumed, and the natural flow of the wells must soon become exhausted. Gas in the great fields of Pennsylvania and Ohio is a thing of the past, if the natural flow of the wells is to be relied upon for the supply. Affairs are in a distressing condition in those States, and especially in northwestern Ohio, as all the towns are left burdened with debt and with no other resources at their command. Their era of prosperity is at an end, so far as it depended upon natural gas. In many of these towns, as a natural result of the criminal waste of nature's most valuable fuel, and the unnatural business excitement and wild speculation that obtained for years, it may be truthfully said that "their last days shall be worse than their first." It remains to be seen whether the same disastrous conditions will mark the end of natural gas in Indiana. About the time that natural gas began to fail in Ohio and Pennsylvania, the great fields of Indiana were discovered, and their vast extent, as well as the apparent stability of the supply of the wells, seemed to warrant the belief that at last a permanent supply had been found. As a result of this discovery and the failure of the Ohio fields, the factories accepted the offer of the cities and towns in the Indiana gas field and removed their plants to this State. The loss of these factories to northwestern Ohio caused a terrible panic and collapse throughout that gas belt, and fortunes sank from sight as values declined to their normal conditions. Over $300,000,000 has been invested in this State in manufactories, and others are now being erected throughout the gas belt. Pipe lines were run to the gas field from Chicago and from many of the principal cities and towns in the State, and every effort has been made to gobble up as much of the territory as possible. Slowly the ends of these pipe lines have been converging to a given point, until now but little of the gas belt remains to be developed.

Already wells are being abandoned every month, and the rock pressure in many parts of the field is rapidly diminishing. The average field pressure has slowly but surely fallen off, and now stands reduced from 320 pounds original pressure to 240 pounds average pressure over the field.

At the rate of pressure reduction that is now going on, and by a continuance of the present extravagant and wasteful method of consumption, it is only a question of a very short time when artificial pressure will have to be used to force the gas through the pipe lines.

Indiana has the largest and best gas field ever discovered, and as no new fields are in prospect, it seems that these are the best fields that will ever be brought into requisition for manufacturing purposes.

A system of the strictest economy should be enforced, and the remainder of the precious gas should be distributed to the consumers as ordered by special acts of the legislature.

Immediately upon the discovery of natural gas in Indiana an era of prosperity began that has been unparalleled. Immense manufacturing establishments were located, and in time, when their fires, fed by nature's best fuel, started, great trainloads of their products were sent out from the gas belt every day. Villages became prosperous towns, and towns grew in a few months into thriving cities, and lots were sold at high prices many miles from their centers.

One of the worst features of the excitement that has prevailed was the belief in the idea that natural gas was to be perpetual.

This belief fostered extravagance and waste. It can be shown from facts obtained and recorded in this department that the waste of gas during the first four years after its discovery in the fields of Indiana amounted to more than $20,000,000.

The supply in many places began to fall short, and there was much suffering during the hard winter of 1892-93. A great many factories in the towns deriving their supplies from this gas field were shut off from the lines and asked to burn coal.

These stern conditions have at last aroused the people to view the situation in its true light. Much of the extravagance and waste has been stopped. Men are seeking to find out the best means for husbanding what remains of this valuable fuel.

The supply of gas is certainly failing. It may not be possible to tell just how long it will last, but the final exhaustion is inevitable.

The following is the pressure found in the different localities during the year 1893. At many of the places, however, the pressure given was obtained only from new wells at a distance of two to four miles from the towns, the wells in the towns and immediate vicinity showing far less pressure, and many wells being practically exhausted:

	Pounds.
Greenfield, Hancock County	250
Carthage, Rush County	120
Noblesville, Hamilton County	240
Sheridan, Hamilton County	240
Kokomo, Howard County	250
Marion, Grant County	250
Gas City, Grant County	300
Fairmount, Grant County	300
Elwood, Madison County	300
Frankton, Madison County	300
Anderson, Madison County	240
Alexandria, Madison County	300
Summitville, Madison County	300
Chesterfield, Madison County	290
Muncie, Delaware County	240
Albany, Delaware County	280
Eaton, Delaware County	290
Hartford City, Blackford County	260
Montpelier, Blackford County	250
Camden, Jay County	225
Dunkirk, Jay County	275
Greensburg, Decatur County	175
Fountaintown, Shelby County	210
Waldron, Shelby County	225

The gravity of the situation can only be understood when it is known that from 225 to 250 pounds pressure at the head of the main lines is absolutely necessary to force the gas to the different cities that lie outside, but are obtaining their fuel from the gas field, with sufficient pressure to distribute it through the low pressure city lines to the consumer. And this pressure, too, is needed when all the reducing stations and district valves are wide open and every facility afforded for free circulation.

What must we do? Are we willing to go back to the use of wood and coal? After having enjoyed the conveniences and luxuries of natural gas for so long a time, to do so would be a great hardship. In order to avoid doing so, or at least to put off the evil day as long as possible, consumers should be willing to adopt any method that would preserve this fuel and perpetuate its use for the longest possible period of time.

In order to do this, I have the following suggestions:

(1) All gas should be sold by meter measurements, and this should be enforced by law.

(2) Natural gas should not be used in the manufacture of bricks, tiles, nor in the rolling mills nor melting furnaces of glass factories. In these factories a coarser and less valuable fuel can be used.

The highest and best purpose to which natural gas can be applied is the domestic use. It is in this use that it does the greatest good to the greatest number, and it is for this use that it should be preserved.

Natural gas is a commodity, and a very valuable commodity, and every other commodity in the commercial world is sold by weight or measure. Experience has shown that this is the only just and equitable way of selling natural gas. The price per thousand feet should be approximately the same as charged in cities where conditions are similar. The following are the net meter rates per 1,000 feet charged in other cities: Detroit, Lima, Piqua, Dayton, Springfield, Toledo, Buffalo and Columbus, 25 cents; Pittsburg, Alleghany and Erie, 22½ cents; Jamestown and Corry, Pa., 21·6 cents; Fostoria and Logansport, 20 cents; Indianapolis, Richmond and Fort Wayne, when sold to manufacturers by meter, 10 cents.

When the time comes that consumers will be compelled to pay for what they use, then, and not till then, will economy be practiced.

One of the great wastes of natural gas that exists in Indiana gas fields is the leakage from pipe lines. During the early days of the fuel, when most of the pipe lines were laid, experience had not then taught the necessity of using the best pipes and fittings. Cheap pipe and cheap connections were the rule. Especially is this true in what is known as "farmer lines," that is, lines that supply people who live in the country. These lines, as well as many that supply the towns and cities, were laid by persons of no experience, and were not tested as to their capacity to withstand high pressures. The result was that leaks were at almost every connection in many of these lines. Much improvement, however, has been made in many of these plants. Better material and better work has been substituted. Especially is this true of the plants that have been put in more recently. Good material is now used, and the lines are thoroughly tested before being subjected to the pressure from the gas wells. A fair estimate of the results of these improvements would be that the loss from leakage from the pipe lines has been reduced more than one-half. Not only was there a great loss of valuable fuel from this source, but there was a great danger to life and property. Many accidents have occurred that have resulted in the loss of life and the destruction of much valuable property that can be directly traced to leakage in pipe lines and mains.

All pipes used for the conveyance of natural gas should be tested by hydrostatic pressure up to at least 300 pounds to the square inch, and the pipe should be rapped with a hammer while under pressure.

Cast iron pipe may be generally used for low pressure, but it should not be used for high pressure mains. In conveying gas under a pressure of 50 to 250 pounds to the square inch, only the best of lap-welded wrought iron or steel pipes should be used. And on this kind of pipe, when the threads are cut, the metal should be made thick, so that the pipe shall not be reduced in strength at that point. One source of great weakness

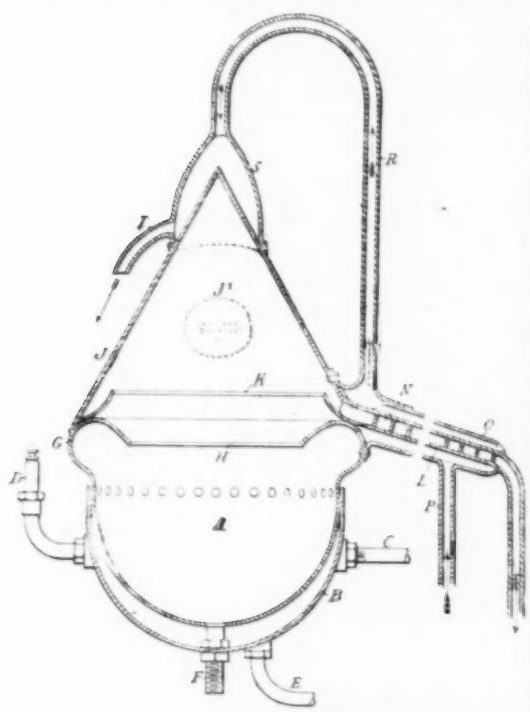
* In the annual report to the State Geological Survey, some interesting observations are made, especially pointing to the necessity for careful economy in the use of natural gas. We make a few abstracts.

is in the special fittings. They should all be made of the best malleable iron or steel. Many companies are now having their fittings made to order, much heavier than those generally found in the market. Even the best wrought iron and steel pipes should be subjected to a hydrostatic pressure at least three times as great as any pressure that it will be subjected to in use.

By a special act of the General Assembly of Indiana, of 1891, the pressure in high pressure pipe lines is limited to 300 pounds.

AN IMPROVED STILL.

THE figure is a sectional elevation of the still, which consists of a hemispherical body, A, bellied or swelled out at G, with a recessed lip, H. Over this body is mounted a conical dome, J, having an outlet, L, containing baffle plates, N, to increase the surface area of the condensed liquid which flows through. The spirit or other liquid is introduced into the bowl, A, by means of the orifice, J', and heat is applied by means of a steam jacket, B, or other suitable contrivance. The vapor is compelled to rise centrally by means of the curved lips, H K, and impinges upon the dome, J, which latter is cooled by means of the stream of water passing from the water channel, O R, through the chamber, S. The condensed liquid flows down the sides of the dome, J, and passes away between the baffle plates, N, in the worm, L, being cooled by the stream of water passing in the reverse direction through the annular channel, O. The distilled liquid finally escapes through the pipe, M. The steam jacket has a steam inlet, C, a safety valve, D, and a condensed water outlet, E, while an outlet, F, is provided for cleansing. The steam jacket may be dispensed with and other suitable modes of heating used, while in large pans



AN IMPROVED STILL.

two or more collecting domes, J, may be used.—G. Morris and W. Edney, Bristol, England.

ON THE PRESENCE IN PAPER OF RESIDUAL CHEMICALS USED IN ITS PREPARATION.

By ROBERT IRVINE, F.C.S., and G. SIMS WOODHEAD, M.D., F.R.S.E.

THE simultaneous removal of excise restriction from the manufacture of paper and the publication of newspapers form an era in the Victorian age, and the effect which followed was marked by the great increase of newspapers and their circulation, causing an extraordinary demand for increased supplies of paper.

Thirty years ago, most (if not all) of the paper produced in Great Britain was manufactured from rags: the process then obtaining being the simple and homely one of boiling with weak lyes of soda, followed by the use of bleaching materials in very limited amount. Paper was then practically made up of pure fiber interwoven or felted together. Now cheap papers are a peculiar compound of China clay, stucco, and resin, held together by a skeleton of fibrous material obtained from wood, esparto grass, or straw, from which the fiber is eliminated only by drastic and costly chemical treatment. Had these new raw materials not been at hand, the rag supply of the world would have been insufficient to meet the present wants of Great Britain alone.

As a natural consequence paper fell in price, and expensive chemical operations necessitated the use of cheap loading materials as compensation—while the careful but tedious washing of the fiber or half stuff had either to be partially or wholly done away with.

It is unnecessary for our purpose to enter into the details of this great industry; but a very brief sketch of the modern processes in use will enable us to point out some of the dangers to the stability of paper thus introduced.

RAW MATERIALS.

Esparto grass, wood pulp, and straw, are now practically the materials used in the construction of paper.

At the present day large quantities of the two former are imported into this country. Esparto, a grass from Spain and the north of Africa; wood in the form of dried pulp, prepared principally in Norway, Sweden and Germany, by acting on it with sulphurous acid and sulphites (and the so-called sulphate of soda), also in some cases by the use of caustic soda. This is supplied to paper makers in a dry condition in the form of coarse, thick sheets of a light brown color.

The esparto or grass consists of a fibrous core surrounded by a sheath of silicious and gummy matter, which is firmly attached to the central portion, and to remove which chemicals (usually caustic soda) are plentifully used, the amount required being generally 10 per cent. of the weight of grass employed.

ANALYSIS OF ESPARTO GRASS BEFORE TREATMENT WITH SODA.

	Spanish.	African.
Ash	3·72	3·34
Water	9·75	8·45
Water extract	10·68	10·05
Fat, etc.	2·15	2·51
Cellulose	50·19	50·16
Incrusting bodies	27·23	28·83
	103·72	103·34
Less ash	3·72	3·34
	100·00	100·00

BOILING.

During the boiling process much of the gummy and silicious matter is removed by the alkaline lye, to which it gives a deep brown color, while at the same time a portion of the more delicate fibrous matter of the grass is destroyed. (In the case of wood fiber prepared by the sulphite process this treatment is not required.) The boiled material or stuff is reduced to a fibrous magma by suitable machinery; at the same time the yellow coloring matter and the soda are removed as far as possible by washing, but this is often so incomplete that from 1 to 2 per cent. of soda may be found in the washed stuff previous to the

BLEACHING PROCESS.

For this purpose chlorine, in the shape of a solution of chloride of lime, is employed, in quantity varying according to the quality of the material, but the amount is never less than from 3 to 4 per cent. (equal to from 8 to 10 per cent. of dry bleaching powder) of the grass used, and sometimes even more. The action of this bleaching agent is sometimes accelerated and increased by heat or by the addition of sulphuric acid to its solution, which sets free chlorine and its oxidation acids, the bleaching operation thus being performed very quickly (here also there is a definite loss of fiber). The entire removal of such an amount of chlorine from the bleached pulp by washing is a most tedious and difficult operation and requires an extravagant amount of water such as few ordinary mill supplies could afford. On the other hand, if the chlorine compounds are not entirely removed from the pulp, the destruction of the paper within a brief space of its manufacture is certain, hydrochloric acid being formed by a partial breaking down of the cellulose, which destroys its texture. This was a common enough occurrence when the increased demand sprang up consequent upon the remission of the duty, and when thus carelessly prepared the finished paper after being stored for some time became brittle and so lost its textile qualities, falling to pieces on being manipulated, a serious enough matter in a pecuniary sense for the paper maker, but unfortunately much more so in effect when such paper was used for printing valuable books.

To remedy this evil, advantage was taken of the property hyposulphites possess of decomposing hypochlorites. This cheap material could be more profitably used by the paper maker than the enormous waste of water required to remove the last traces of chlorine from the pulp. Indeed, the general practice which obtains in the present day often merely provides for getting rid of the chlorinated water from the bleached half stuff by pressing out that which can be removed in this manner and then adding antichlor; subsequent washing with water being either very partial or in some cases almost wholly dispensed with.

We have therefore in many bleached paper pulps the products derived from the action of hyposulphites upon the chlorine compounds. These consist principally of chlorides and sulphates, which are in a general sense innocuous, but there is also a notable proportion of finely divided sulphur separated in the process which is precipitated and becomes entangled in the fibers and is thus transferred to the finished paper. The pulp at this stage is generally alkaline, owing to the presence of unsaturated lime in the bleaching solution.

SIZING.

For this operation alum, or acid aluminous compounds in conjunction with resin soap, is freely used. Printing papers may in consequence give a distinctly acid reaction. In some cases starch is added to the pulp, which during the drying of the paper gives it a fine glossy surface. In such papers it is not impossible that there may be organic acids formed as products of the decomposition of the starch in presence of the water which paper attracts to itself when exposed to the damp atmosphere of our climate. This water generally amounts to one tenth of its weight.

To counteract the brown tinge which even well bleached grass or wood fiber always retains, ultramarine blue is added to the finished pulp, which (as already stated) is sometimes of an acid character. When this is so, it gives rise to another source of impurity, the ultramarine being decomposed by the acid; sulphur compounds are set free, which are peculiarly disagreeable, owing to the formation of hydrosulphuric acid. In this case also sulphur is separated and is transferred to the finished paper.*

* Practical paper makers have realized, to their cost, the trouble free sulphur gives in corroding the wire cloth and the dandy rolls which form such an important and costly portion of the paper machine. The sulphur combines with the copper of the brass wire tissue, forming sulphide of copper, and the wire gauze becomes rotten long before it otherwise should be.

The presence of sulphur and its volatile compounds in ordinary paper may be detected very simply.

A small quantity of the paper under examination (about 1 oz.) is placed in shreds in a glass flask and covered with distilled or rain water. The neck of the flask is loosely plugged with a coil of white blotting paper which has been previously soaked in a solution of (basic) acetate of lead and dried. Gentle heat is applied, but the contents of the flask are not allowed to boil, a watch glass is placed on the top of the plug; in a short time the blackening of the lead compound, owing to the formation of sulphide of lead, will show if sulphur, sulphides, or loosely combined sulphur compounds are present.

It is true the amount of sulphur is generally very small, varying from mere traces to 0·5 per cent. in good papers, although it may be present in greater amount in cheap, flimsy newspapers where obviously it does no particular harm; but where such papers are used for printing books or pamphlets, it may give rise to most objectionable results.

The sulphur compounds derived from the use of hyposulphites when that substance is used as an antichlor and those from ultramarine are distinguished in the following manner:

By treating the paper with water alone, as described, if sulphur or sulphides derived from hyposulphites are present, the plug of acetate of lead-soaked paper will become colored by the sulphide of lead formed, rendering it faintly brown or black in color, according to the amount present. If no such coloration occurs, sulphur or sulphides are absent as derived from hyposulphites.

Of course this test is only of value when papers are neutral or slightly alkaline. If the paper gives an acid reaction, the hydrosulphuric acid evolved may be partly or wholly derived from the ultramarine used, but if the paper is neutral and has given no color reaction to the lead paper when heated with water alone, if a few drops of acetic or hydrochloric acid be added to the contents of the flask, coloration at once shows.

Some ultramarines are so unstable that even the carbonic acid present in a loosely combined or free condition in hard waters is sufficient to cause decomposition and evolution of hydrosulphuric acid.

When sulphur and linseed oil are brought into contact there ensues a distinct and well-known chemical reaction, the sulphur breaks up the oil and combines with its hydrogen, hydrosulphuric acid being set free.*

As one of the principal uses of paper is that of a printing medium, and as in all the higher classes of printing ink linseed oil is used as a vehicle or medium for the black or other coloring materials used in its manufacture, if free sulphur or sulphides or volatile sulphur compounds are present, the infallible consequence of using such papers for printing purposes is the production of sulphureted hydrogen and other like products which impart their characteristic and disagreeable odor to the resulting book or periodical.

We admit that even the most carefully prepared printing inks retain the odor of the materials used in their manufacture, but this is very trifling, and we have become accustomed to associate all printed matter with the not unpleasant balsamic odor of the press room, which odor, however, has no relation to the fetid and disgusting smell which is engendered when sulphur is present in the paper used.

These results seem forcibly to show:

I. That the use of hyposulphites as antichlor, even when the antichlored pulp is thereafter thoroughly washed, is unsafe and a mistake.

II. That the introduction of ultramarine to "clear" the brown color of the fiber is also unsafe when acid aluminous compounds are used in excess in the sizing operation.

Both substances under certain conditions obtaining in paper manufacture may introduce, proportionately as they are used, sulphur or sulphides into the paper, with the consequences we have mentioned.

The remedy seems simple, and we advise the substitution of sulphites or bisulphites or even sulphurous acid for hyposulphites, the same end being gained by their use, these reducing agents destroying the active chlorine compounds without sulphur being precipitated. We understand many paper makers now use sulphites in place of hyposulphites.

The most perfect antichlor for chlorine-bleached pulp or cotton cloth would, of course, be peroxide of hydrogen. Could a cheap method of its preparation be found (there are indications that the present costly process may soon be simplified and cheapened), peroxide of hydrogen would then supersede chlorine, presenting as it does the most perfect bleaching agent known.

As regards the use of ultramarine, we would advise the substitution of Prussian or aniline blues (the latter of which, however, is a very unstable color), which cannot under any circumstances give rise to the unpleasant odor of sulphureted hydrogen emitted by ultramarine when acted upon by even weak acids. The increased cost of these coloring matters will be more than recompensed by their higher tinctorial value. It is true that the ultramarine supplied to paper makers is of the most stable character possible to a pigment into the composition of which alkaline or earthy sulphides enter as an essential part, but it must in any condition be a source of danger alluded to.

More complex changes than these we have indicated may occur when paper containing starch and sulphur or its volatile compounds is used for printing purposes, and it is not impossible to suppose that evil smelling bodies allied to the mercaptans may be formed, especially if the paper is in mass as in bound books and exposed to heat and moisture.

The whole question we have raised is one well worthy of most careful study. The evil we refer to has caused much trouble and inconvenience lately, more especially in connection with one of the most widely circulated periodicals of the day, the pages of which, some time since, smelt very vilely. We investigated the matter, and the smell was undoubtedly traced to the presence of sulphur compounds in the paper used; not that this paper was specially bad in this respect, containing only 0·20 per cent. of free sulphur, yet in

* The so-called vulcanizing of linseed oil by this means is a well established process in the arts.

this case the general conditions favored the evil. In the case we refer to hyposulphite had undoubtedly been used by the paper maker (who simply followed the course of his forefathers), and where such antichlor is used, sulphur must be one of the products.

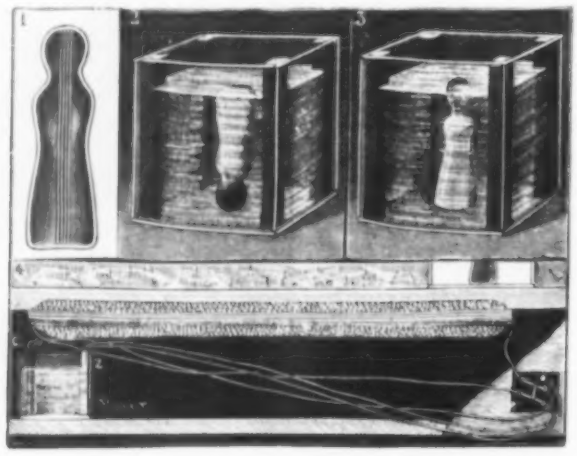
Of the many samples of paper we have examined we have found "Scotch printings" very free from "antichlor sulphur," but almost invariably we have found all papers to contain a notable quantity of sulphides derived from ultramarine.

We have not referred to the existence of these evils in regard to the high class writing papers, but we have no doubt they will be found to exist there also.

The smell of paper and printing ink has in the past been "put up with," but the taste of the reading public has now become fastidious in respect to the physical as well as the moral purity of their mental pabulum.—Jour. Soc. Chem. Industry.

THE MAGIC DIVER.

Into a small square glass box filled with water and placed upon a table, the prestidigitator puts one of those small cardboard dolls that are sold for a few



THE MAGIC DIVER.

cents in toy stores. At his command, the doll salutes the spectators in making a dive. In the same manner it answers "Yes" to questions that are put to it, and, in order to answer "No," it turns upside down and insists, if need be, by striking the bottom of the box two or three times with its head.

Forced cards, loaded dice and other accessories of the same nature, guessed-at thoughts and secrets unveiled by the known processes of physics—all these are utilized in the experiment of the magic diver, in order to make the conversation with the doll last as long as possible, and to well prove that it is endowed with the most wonderful intelligence.

A skillful and painstaking amateur may prepare for himself all that is necessary for the performance of this amusing trick.

The doll, shown in section in the upper left hand corner of the figure, is covered with an insulating substance, such as a solution of rubber in benzine, which renders it impermeable. It contains a bundle of knitting needles magnetized by the known processes. The box may be easily constructed as follows: At the four corners of a square piece of very thin wood rise perpendicularly four pieces of an ordinary wooden ruler. Four plates of glass (such as those used for taking photographic negatives, for example) form the sides of the box. They are fixed to the wooden bottom and the uprights by means of a glue made of bichromated gelatine (one part of bichromate to five of gelatine), which is afterward rendered insoluble by an exposure of a few hours to sunlight.

In the interior of the prestidigitator's table (No. 4) there is an electro-magnet about three inches in length, fixed against the top of the table, which has been hollowed out to receive it, in order to diminish as much as possible the distance that separates it from the diver, which will have to be placed above one of its extremities.

Our vignette (No. 4) represents upon the posterior side of the table an interrupter which is at the same time a current commutator of the same kind as that with which small Ruhmkorff coils are usually provided. In the interior of the table a battery, C Z, may likewise be observed. The prestidigitator might, at a pinch, maneuver the apparatus with the thumb of his left hand, by carelessly resting it upon the posterior edge of the table, while he commands the diver with the magic wand held in the right hand, but, in practice, it is better to place the battery and commutator in the side scenes or in an adjoining room. It is always easy to conceal two fine conducting wires under the carpet and along the legs of the table, one of which might be pierced for its reception.

The difficult point is to ballast and balance the diver properly. This may be done by means of leaden balls or of brass pins inserted here and there into the sides of the doll, or, on the contrary, by the application to it of sheet wax moulded by the heat of the hand.

The total weight of the diver should be but little less than that of the water that it displaces, and the quantity of liquid should be measured in such a way that the doll, when in a vertical position, shall not be more than a quarter of an inch from the bottom of the box, unless the electro-magnet used is powerful enough to permit of a greater distance.

It will now be understood what takes place. When the electric current is sent in a direction such that the pole situated under the box shall be of a contrary name to the one opposite the magnet of the diver, the latter will be attracted and make a dive. If the current be reversed by means of the commutator so as to change the orientation of the electro-magnet concealed beneath the table, the opposite side of the doll will be attracted, and the latter will turn head over heels from that direction.

This experiment is as amusing as it is curious for amateurs of physics.—La Nature.

THE ARRANGEMENT OF DESSERT FRUIT.

While examples of floral arrangements are frequently met with upon which no small amount of taste and care have been expended, it is a far rarer occurrence to see a dessert so arranged as to deserve the same amount of commendation. Flowers are looked upon perhaps by some as the all-important factors in the disposal of a dinner table, but this is altogether a mistaken idea, for the two should be harmoniously blended together. We have the framers of prize schedules to thank beyond a doubt for the preponderance given to flowers in competing exhibits of this description; there is, however, no reason why this should prevail to nearly that extent which it does at the present day. In the arrangement of dinner tables in the home there is even the same disposition to ignore the graceful grouping of the dessert in favor of the flowers. This idea should be overcome, allowing the same amount of care in one case as in the other. When prizes are offered for a dessert table, i. e., fruits and flowers in combination, the former is often ignored as forming a part of the general effect, and very little time is given to the arrangement of it. This occurred at the Crystal Palace in May last in the premier table fully laid, and I have often noted it at other places. The same blending of tints and colors throughout the entire arrangement will produce a most pleasing effect, whether at home or in competition. It is not, however, to the floral portion I now wish to allude, but the fruit itself, more particularly what is termed the "dishing up." In doing this another allusion is needful to exhibitions, not in this instance to exhibits of taste so much as that of culture. By this I mean collections of fruits for dessert which are never arranged as for dessert, but if they were, the effect of the whole would be much better. We have the grapes invariably retained upon the sloping boards, and the pineapples stood upon inverted flower pots, and the rest of a collection upon plates. Why not have all displayed upon dessert dishes, more particularly when the prizes are sufficiently remunerative? True we have not ideal dishes for grapes. I have not seen one dish yet that meets with this definition, but I have in my mind's eye what I should prefer, and may have more to say on this point another time. The best should, however, be made of such as we can secure in the case of exhibitions. If this were done, the collections of fruits would be additionally attractive, and when done tastefully it would afford some idea of service in the home work as well.

One most essential point in arranging dessert is to avoid overcrowding, yet upon what are considered special occasions it is the one error thas so often prevails. It should be understood by those who arrange the dessert that large quantities of fruit piled up in one mass are not nearly so effective as smaller dishes. The overcrowding of fruit stands in a similar position to the overcrowding of flowers, but it is even less recognized. Large dishes of fruits, again, are not nearly so convenient for circulation among the guests as smaller ones. One or two bunches of grapes makes a far better dish than twice the quantity, size being equal, while in the case of grapes and other fruits, too, it should be carefully noted that the larger the dishes, the more is there of the fruit hidden from view. This fact is clearly exemplified in the illustration of the basket of pears which accompanies this article, in which, if the number of fruits were increased, the effect would not increase in a like ratio. Large dishes of strawberries, of cherries, of gooseberries and other small fruits are also absurd. More than one such carefully piled up cone of fruit has been passed by when offered to a guest, for fear of some of it falling off in the process of helping one's self.

The dishing up of the fruit in a formal manner, every separate one being made to stand or lie just so, is another fallacy. Again, note the method of arrangement in the case of the pears on this point. There is no valid reason why the stalks of cherries and strawberries should all be hidden as if they were a disgrace, but this is oftentimes carefully executed. No; on no single point is there anything advantageous to be learned in the arrangement of fruit in exhibitions; it is rather what to avoid, although the individual culture in each instance may be quite first class. It is a waste in very many cases to make up such large dishes, being in no sense needed, for a display of fruit in quantity after the repast is over means so much waste when it exceeds a judicious margin. The after handling of ripe fruit will in no way improve its appearance or its quality for another occasion, while in the case of such fugitive fruit as the strawberry and the raspberry it is never possible to use it the second time. In some instances, as in the case of tender skinned pears (Jargonelle, Williams' Bon Chretien, and Marie Louise being examples), it is a very easy matter to spoil their appearance if not carefully handled, and this can hardly be done so effectively in small dishes as in larger ones. There is, in fact, a deal of room for improvement in the handling of fruit before it finally reaches the dessert plate. This does not occur so frequently when the grower dishes up his own productions, for he knows what the consequences will be. It does, however, when in the hands of those who are none too well acquainted with the individuality of each respective kind. Both peaches and nectarines frequently receive indented finger marks, oftentimes upon their rosy cheeks. Pears, too, come in for the same thoughtless handling, and in each case can these marks be traced upon the removal of the skin. Apples may need a careful wiping with a soft linen cloth when dusty or after storing, but such work should not be attempted merely to polish the fruit. Grapes I have personally seen taken up in the hand, with an utter disregard for the bloom upon the berries, and that after every pains have been taken to keep it intact. No dessert fruit probably comes in for such thoughtless handling as grapes. Plums have frequently but little semblance of bloom upon them when dished up; yet what is there more beautiful than a perfect specimen of Kirke's or Transparent Gage with the bloom well preserved? From the want of better information, those who dish up fruit often make a mistake in placing too much reliance upon appearance or color. I once heard of Beurre de Capiaumont pears being chosen in preference to Doyenne du Comice for this reason.

BASKET OF PEARS FOR TABLE DECORATION.

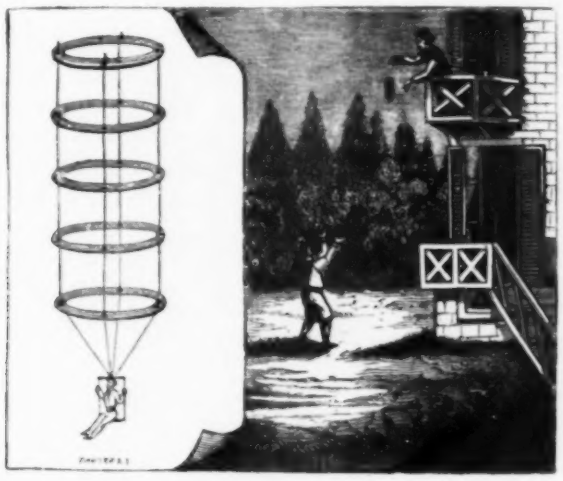
Fruits which quickly pass off from their high flavor, as in melons, need to be carefully watched, so as not to send a markedly over-ripe fruit to table.

The accessories to the dishing up of fruit are chiefly leaves, nothing on the whole being better than vine leaves, particularly as with age they assume their rich and varied tints. This, too, is shown well in the illustration with the adaptation of the shoots as well to a suitable purpose. In the use of vine foliage it is possible to vary the tints considerably, so as to suit each to the fruit itself. Sprays of the Virginian creeper, both the large and small forms, are lovely appendages to any dessert; so also is the smilax or Myrsiphyllum asparagoides for entwining around basket handles or

stems. Although the term "dishes" is most in use (and mostly used), a word should be said in favor of baskets, which afford a most welcome change; the use of the latter is strongly advised for luncheons and mid-day decorations.—The Garden.

A TOY PARACHUTE.

CUT out a piece of thin cardboard or thick paper five or six rings, as shown to the left in the accompanying figure. Place these one upon top of the other, and, with a fine awl, bore four holes through them corresponding to the extremities of two diameters at right angles. Afterward, connect the rings by means of four threads, provided with knots that will keep them

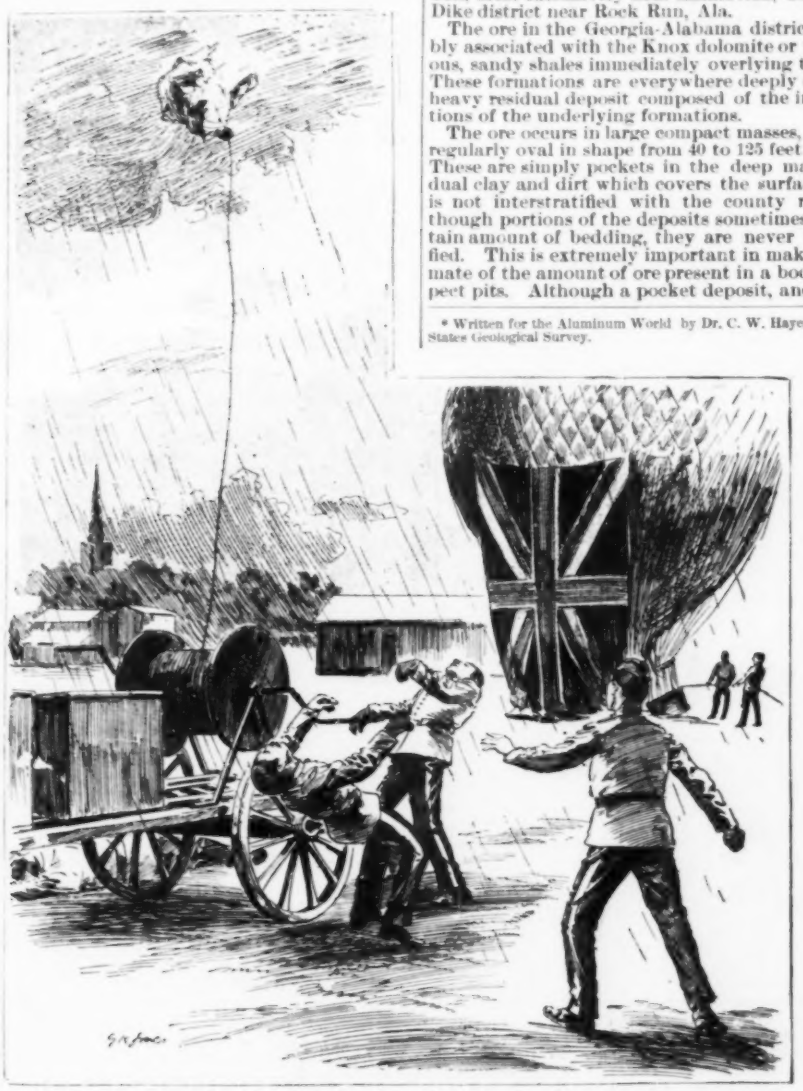


A TOY PARACHUTE.

about three quarters of an inch apart. Afterward suspend some sort of a small figure from the extremity of the threads and allow the whole affair thus weighted to drop from a certain height. The apparatus, forming a parachute, will descend slowly and gracefully to the great delight of a group of youngsters ready to catch it.—La Science en Famille.

A MILITARY BALLOON ACCIDENT.

A MILITARY correspondent, an eye witness of the alarming incident which recently took place at Aldershot during some experiments before the Duke and Duchess of Connaught, sends a sketch of the accident to the Daily Graphic, London. The occasion was the launching of a new large balloon, in which Lieutenant Baden-Powell, of the Scots Guards, and two sergeants were about to make an ascent. The small balloon Flo was, however, first sent up captive, carrying a royal standard to denote the presence of the august visitors. A thunderstorm coming on, this balloon was suddenly set on fire by the electric discharge, and three men who were winding the winch to which the captive rope was attached were thrown down and so badly injured by the shock that they had to be taken to the hospital.



A MILITARY BALLOON STRUCK BY LIGHTNING.

CHIEF SOURCES OF ALUMINUM.*

UNTIL some radical change is made from the present method of reducing aluminum, bauxite must continue to form the chief ore from which the metal is obtained. It, therefore, becomes a matter of interest to the manufacturer and to the public generally to know something of the mode of occurrence and origin of this mineral, and more especially the extent of the deposits. It is of interest to know whether the known deposits are sufficient to supply a continually growing demand and whether the productive area will probably be greatly extended.

The mineral has been found in commercial quantities in only two localities in the United States, viz., in Arkansas and in the southern portion of the Appalachian valley, and it is only in the latter that it is being developed on a large scale. The ore bodies are found within a narrow belt of country extending from Adairsville, Ga., southwestward a distance of sixty miles to the vicinity of Jacksonville, Ala. The ore has been worked at some half dozen points within this belt, most extensively near Adairsville, Ga., and in the Dike district near Rock Run, Ala.

The ore in the Georgia-Alabama district is invariably associated with the Knox dolomite or with calcareous, sandy shales immediately overlying the dolomite. These formations are everywhere deeply covered by a heavy residual deposit composed of the insoluble portions of the underlying formations.

The ore occurs in large compact masses, generally irregularly oval in shape from 40 to 125 feet in diameter. These are simply pockets in the deep mantle of residual clay and dirt which covers the surface. The ore is not interstratified with the county rock, and although portions of the deposits sometimes show a certain amount of bedding, they are never truly stratified. This is extremely important in making any estimate of the amount of ore present in a body from prospect pits. Although a pocket deposit, and in this respect analogous to the limonite deposits of the same region, they differ materially from the latter. The iron ore is in extremely irregular masses, from a few inches to scores of feet, and penetrating the residual material in all directions within considerable areas. It also occurs disseminated through the residual material, from which it is removed by screening and working. Bauxite, on the other hand, generally occurs in compact bodies with more definite boundaries than the limonite. Wherever the ore has been removed sufficiently to show its contact with the surrounding residual deposits the contact is generally sharp and nearly vertical.

The depth of the ore bodies is not known, and workings to the depth of 25 to 40 feet have not reached the bottom. It is not probable that the ore reaches much, if any, below the bottom of the residual mouth. The extreme thickness of the latter is not known, though it has been observed at a depth of 80 feet or more.

The structures of the different ore bodies vary somewhat, although not in any essential particular. In the Julia mine, southwest of Adairsville, Ga., the ore is quite uniform throughout. It is coarsely pisolitic, the individual pisolites being from one-fourth to two inches in diameter. The ore body looks like a mass of partially compacted gravel without any sign of bedding. Scattered throughout this pisolitic mass are well rounded bowlders of more compact ore, from a few inches to two feet in diameter. The smaller pisolites are composed of a rather soft, porous nucleus, which is surrounded by many concentric layers of compact bauxite. The nuclei of the larger nodules and bowlders are generally fragments of ore composed of a hard, compact matrix in which soft pisolites are embedded. This is the character of the ore in most of the deposits south of Rome. In the latter, especially those of the Dike district, there is considerable variation, beds of compact oolitic ore alternating with those which are coarsely pisolitic, and others of fine grained compact material containing only scattered pisolites or none at all, and breaking with a conchoidal fracture.

The ore is generally light gray in color, but varies from chalk white to deep red. The white color occurs where the ore is very loose texture and crumbles into a fine powder, as in some parts of the War Whoop and Bobo banks. The red color is produced by the presence of iron and appears most commonly about the edges of the deposits. In some cases the iron forms only a thin film surrounding the pisolites, which are white within; in others it is uniformly distributed, so that both matrix and pisolites are red. The ferruginous bauxite usually forms but a small proportion of the ore body.

From its mode of occurrence the process of mining the ore is the simplest possible. All work thus far has been done in open pits similar to the limonite banks so abundant in the same region. Since the bauxite occurs in more compact bodies, less dead work is required than in mining the limonite. The surface soil, from three to six feet in thickness, is removed, and the ore is exposed ready for removal. It is generally soft enough to be worked with pick and shovel, but in some cases requires blasting. An open trench usually serves for drainage of the surface water, though in some of the banks the work has gone too deep for drainage, and a simple pumping or boiling device is employed. The ore is sorted in the pit and dried by spreading out in the sun a few days before shipment. At the Julia banks the coarse pisolitic ore is screened to separate the pisolites from the fine granular or powdery matrix. The latter is probably nearly as good ore as the pisolites, but is not being shipped at present. At this bank a portion of the ore is dried by wasting in the open air. Considerable moisture is driven off in this way, and the weight of the ore materially reduced.

The geologic conditions under which the ore occurs and its probable mode of formation are of practical as well as scientific interest, since they afford a clew in the search for other deposits in this and other regions. The ore makes but little show at the surface, since it is about the color of the Knox schist, but is very much less durable. Its associations, however, are such that the area within which there is probability of finding it is very much restricted. The more important of these conditions are as follows: The deposits are invariably underlain by a calcareous formation, the Knox dolomite, being surrounded by the residual material resulting from its decay. As already stated, their relation to the dolomite itself is not known—whether they rest upon it or in cavities within it, or are entirely within the residual mouth. In the second place, the deposits, so far as known, are either directly upon or very near lines of faulting, along which the rocks have been fractured to great depths. Finally, they occur well up the sides of the dolomite ridges, though not on their summits, at elevations between 800 and 900 feet above sea level.

These conditions under which the ore is found not only restrict the area in which search for it may faithfully be made, but also throws light upon its probable mode of origin. There is no rock in this region which could yield bauxite as a residual product; hence a satisfactory explanation of the origin of these deposits must give the source from which the material was driven, the means by which it was transported and the process of its local accumulation. As stated above, the ore is always associated with the residual material derived from the Knox dolomite or with calcareous sandy shales immediately overlying the dolomite. At a greater or less distance below the dolomite is a great mass of fine aluminous shales, and these are probably the source from which the alumina forming the ore was derived. The ore-bearing region has been extensively faulted, and it was mentioned above that the ore bodies are closely associated with these faults. Such enormous dislocations of the strata, in most cases measuring many thousand feet, undoubtedly generated a large amount of heat. The fractures also facilitated the circulation of underground water, and for considerable periods the region was probably the seat of many thermal springs. These heated waters appear to have been the agent by which the alumina was brought to the surface in some suitable form, and there precipitated.

The oxygen contained in the meteoric waters, percolating at great depths through the fractured strata, would readily oxidize the sulphides disseminated through the aluminous shales. Sulphates would thus

* Written for the Aluminum World by Dr. C. W. Hayes, of the United States Geological Survey.

be formed by a process strictly analogous to that formerly employed in the manufacture of alum. Probably the most abundant product of the process in nature was ferrous sulphate. Some sulphate of aluminum must also have been formed, together with the double sulphate of potassium and aluminum. In its passage from the underlying shales through several thousand feet of dolomite, the heated water must have become highly charged with lime, in addition to the ferrous and aluminous salts already in solution. But calcium carbonate reacts upon aluminum sulphate, and to some extent, also, on alum, forming a gelatinous or flocculent precipitate, which consists of aluminum hydroxide and the basic sulphate. This reaction may have taken place at great depth, and the resulting flocculent precipitate may have been brought to the surface in suspension. The precipitate was apparently collected in globular masses by the motion of the ascending water, and constant changes in position permitted these to be coated with successive layers of more compact material. Finally, after having received many such coatings, the pisolites were deposited on the borders of the basin, and the interstices were filled by minute oolites formed in a similar manner or by the flocculent precipitate itself. A small portion of the ferrous sulphate was oxidized and precipitated along with the bauxite, but the greater part was carried some distance from the springs and slowly oxidized, forming the widespread deposits of limonite found in this region.

An interesting question arises as to the supply of bauxite and the possibility of its being exhausted in the near future. No estimates have been made of the amount of ore in sight in the various bodies which are being worked, and none can be made which will have any claims to accuracy till at least one representative ore body is thoroughly exploited and the depth ascertained. The ore may reasonably be expected to reach a somewhat greater depth than the limonite deposits of the same region, which seldom go more than 25 or 30 feet below the surface. The chemical reactions by which the iron was precipitated required the presence of air, and hence the reaction was superficial. The alumina, on the other hand, was probably precipitated before it came in contact with the air, and hence may reach greater depths.

The development of these deposits is as yet in its infancy, and the opinion prevails that they are inexhaustible, but the same opinion prevailed a few years ago concerning the limonite deposits of this region, many of which are now exhausted. Additional deposits will doubtless be discovered in the region at present productive, and less ore will be wasted in mining, but it is probably only a matter of a few decades till even the present rate of consumption shall exhaust these deposits.

The conditions under which large deposits of alumina could accumulate have been far less prevalent in past geologic ages than those which favor the accumulation of iron oxide, and hence localities for bauxite are rare, while the ores of iron are more abundant than of any other metal. The favorable geologic conditions, so far as they can be ascertained, are present in other portions of the southern Appalachians, extending nearly to Central Alabama and through Tennessee and Virginia. Other conditions which are not yet known may restrict the ore to the present productive belt, but it is rather more probable that similar deposits will be found in other localities where the geologic conditions are the same.

[Continued from Supplement, No. 980, page 15667.]

PHOTOMETRY.*

By Capt. W. de W. Abney, C.B., F.R.S.

LECTURE II.

I omitted, from want of space, to say in my last lecture that the fact that a flame viewed end on is from 10 to 35 per cent. less luminous than when viewed sideways. Fig. 1 gives a measurement if taken with a

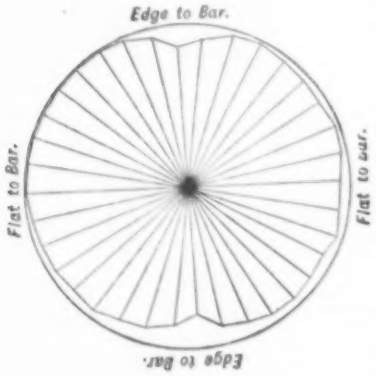


Fig. 1.

flame at different angles to the screen according to Mr. Dibdin. The variations in the light of a burning candle have been shown you, and I think that for scientific working it must be dismissed as unworthy of serious consideration. There are only three what I may call feeble light standards which I shall refer to, viz., the amylacetate lamp, due to Hefner Alteneck; the pentane illuminant, and the ether illuminant. I put the amylacetate lamp first, not because of its superiority, but because it requires such little manipulation. This is a lamp which is a great favorite of mine because it is so accordant in its results. It consists of a tube of German silver, 8 mm. in diameter and 25 mm. high. The flame is 40 millimeters high, and when it has been burnt for five minutes the flame remains of a constant height. It burns amylacetate, but it is not necessary to use this compound, as any similar one will consume as well. Hefner Alteneck gives a table of the results of the different compounds and their comparative luminosities:

	Constitution.	Per cent. of carbon.	Boiling point.	Intensity of light.	Time for the combustion of 1 gramme of the substance.	Carbon consumed in 100 seconds.
			C.			
Valerate of amyl	$C_{10}H_{10}O_2$	69·7	195	1·03	430	0·162
Acetate of amyl	$C_7H_{14}O_2$	64·6	138°	1·00	388	0·166
Formiate of amyl	$C_6H_{12}O_2$	62·1	122°	1·01	372	0·163
Acetate of isobutyl	$C_6H_{12}O_2$	62·1	116	0·99	373	0·163
Formiate of isobutyl	$C_5H_8O_2$	58·8	98	0·97	355	0·166

The drawback to this lamp, as originally constructed, is that the metal takes a green deposit, which is tiresome: if it be plated with silver, this disappears.

Dibdin's pentane Argand, which burns pentane, is the next one to refer to, and is the lamp which appears to me most perfectly to utilize the pentane, employed as an illuminant, in a simple method. Pentane is a hydrocarbon of the paraffin series, but is not perfectly pure at all times. The illuminant is air passed over a carbureter containing the pentane. The height of the flame is 3 inches, $\frac{7}{10}$ of which are cut off by a screen at the top. By these means a standard flame is obtained, which is equal to 10 candles. The great point in this is that the height of the flame does not affect the result, at least it does not to the eye. Temperature has no effect on the result, as Mr. Dibdin has thoroughly tried.

The next standard is a very simple one, introduced by Mr. Dibdin more especially for photographic purposes; ether, instead of pentane, is burnt in a pentane lamp, and gives a very fine light. Photographs

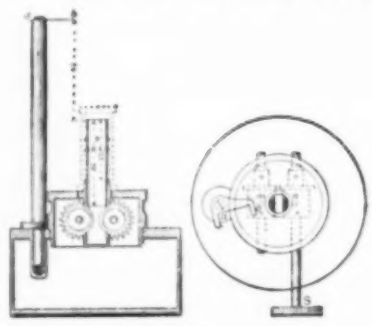


Fig. 2.

taken with these two lights at different heights of flame, but of the same visual intensity, do not give quite the same photographic effect, so that there is a deviation from the definition of perfect standard.

We have seen what kind of a light we must use for photometry as to quality and quantity. Now we come to photometers. The photometry we will first consider is the comparison of two lights together. How are we to compare two lights? There is one evident way, and that is to place side by side two white surfaces which are illuminated by the two lights. This is the principle of Rumford's photometer and nothing else. We are usually told that it is the method of shadows—the comparison of shadows one with the other. Now it is nothing of the kind, it is really the illumination of a surface by two distinct lights, the one illumination being not interfered with by the other, and this is secured by making one light cast a shadow of a rod on the screen, which is illuminated by the other, and this last light to cast a shadow of the same rod at a different place, which is illuminated by the first light. These two illuminated surfaces can be made to touch by moving the rod or the angle of the light, and by various plans these can be equalized in brightness. No less a distinguished authority on photometry than Mr. Dibdin, in an excellent book he has writen, says, although this method has certain advantages, "the method is one which few practical photometrists of the present day would venture to adopt." Well, I am a

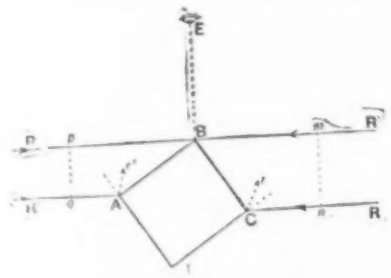


Fig. 3.

tolerably practical photometrist myself, and I must confess I prefer it to any other kind of photometry, as it is simple, and very few errors can creep in if one is ordinarily careful, which is more than can be said of some others, as we shall see. One error that may be met with is that if the lights make a great angle with each other, and if the screen is not placed at right angles to the line bisecting the angle, an error may creep in.

Let me show you this experimentally, and this experiment really demonstrates another mode of photometry.

This white cube is placed between two lights, one of the right angles of the cube being toward you. I place a square aperture in front, so that it is bisected by the edge. The cube is rotated round that edge as a center, till the two sides appear equally illuminated. The reason of the equality of illumination is quite plain. It is because the side nearest the light is skewed at a greater angle than the other to it. If we have a diagram, we shall see why this is. In Fig. 3 A B and B A are the two sides of the cube illuminated by rays, R and R. It is evident that the side, A B, will not receive so many rays as B C, in fact, the amounts are measured by p q and m n. If the lights are unequal, of course when the intensity of the one multiplied by p q is equal to the intensity of the other multiplied by m n, the two will equal. The intensities, where a balance is struck, are found by taking the cosines of the angles through which the cube is turned.

We now see that light illuminating a surface varies as the cosine of the angle through which it is turned. If it be turned 5° more toward one light than the other, it is evident that we shall get a variation. The amount would be as 1 to 0·996, or an error of $\frac{4}{1000}$, or $\frac{1}{250}$. If it were 10°, it would be 1 to 0·984, $\frac{16}{1000}$, or $\frac{1}{62}$ part, which would be appreciable.

There is still one more error which might be felt, and that is that the eye receives more light when the angle which the screen makes with the eye and the source of light is greater than a right angle (see r and r, in Fig. 3). This must always be the case, but what may be called the difference in the specular reflection is so small for ordinary angles, that it is of the same order as that given for the wrong placing of the screen, and becomes practically negligible.

For great accuracy the illuminated shadows should touch, and if the lights be not too broad, there is no difficulty in causing this to be done; sometimes, however, a white line or a black line will separate the two, owing to the penumbra of the shadows, and then making the illuminations of the two strips equal becomes more difficult. As the black line has greater contrast to the two illumined surfaces than the white line has, the former is the worst kind of line to put up with.

The next method that is adopted is what is known as the Bunsen method. It consists of equalizing the brightness of a greased spot in the center of a paper disk, or its total disappearance. The principle on which this is based is the translucence of the spot. If as much light goes through the spot (if perfectly made) from one light as goes through from the other, the spot is equally illuminated throughout its thickness, and appears the same whiteness as the paper. If it be greater on one side, it will appear dark on one side and lighter on the other. It is evident that with such a method every suspicion of stray light must be rigidly excluded, unless it be exactly the same on both sides of the disk, and only that coming directly from the sources of light utilized. Light reflected from the sides or bars will give fatal results as far as accuracy is concerned. I have met with some instruments in which reflections seem to have been encouraged rather than allayed. To my mind the method should not be accepted except in the hands of those who are thoroughly practical and scientific. I show the design of a Letheby photometer, kindly lent me by Mr. Sugg. [The instrument itself was in the lecture room, through Mr. Sugg's good will.] The grease spot is viewed on both sides by inclined mirrors, and when the grease spot disappears on both sides, or at all events appears to be equally dim on each side, the light illuminating the spot may be said to be equal.

There is one thing to be noted, and that is that very much depends upon the kind and amount of grease, and the kind of paper employed. I have made a good many grease spots in my day, and I have found the sensitiveness of the method vary considerably according to the attention paid to these details, but I have abandoned the method in my laboratory, except under special circumstances, in favor of the old Rumford method.

Mr. Dibdin, in his work, says:

"When first setting up a disk for use, special experimental readings should be taken; and if any material difference is found between the indications when one side or the other is turned toward the standard flame, it should unhesitatingly be rejected, as no amount of after allowance can compensate for the trouble and doubt arising from contradictory results. The disk should be clean and perfectly free from scratches or other markings of any kind; it is but sorry economy to work with a defective instrument. The gas referees went so far, a short time back, as to run a new disk, to be used every week. As, however, a good disk when taken care of will last much longer than that period, the point has not been insisted upon; but that is no excuse for the continued use of a defective one, which should be instantly destroyed as soon as detected."

We see from this that a disk photometer is open to a very grave objection, and it is for this, if for no

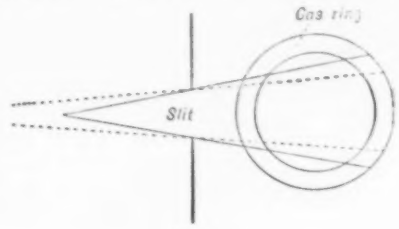


Fig. 4.

other reason, that I prefer the Rumford system, where there is no liability to err on this matter. A modification of the Rumford method of shadows is that employed by Prof. V. Harcourt. He casts his shadows on ordinary printing paper, rendered partially translucent by a wash of spermaceti dissolved in petroleum. Instead of a rod, and about three-quarters of an

* Lectures delivered before the Society of Arts, London, 1894.—From the Journal.

inch from the paper, he places a brass screen, having two rectangular apertures cut in it exactly their own breadth apart. The two lights are placed at equal angles on each side of the line perpendicular to the screen, and the illuminated shadows are caused to just touch one another. It will be noticed that really there are four shadows illuminated, one from one light being touched by the other two and the fourth falling on an opaque or black space. A great advantage of this plan is that they are looked at from the back of the screen, no rod being between the eye and the screen. If two lights of approximately the same color are looked at, the fact that the light has to traverse the paper is of no moment, though, when colored lights have to be compressed, there is a danger of absorption, slightly altering the values that should be obtained.

Before quitting the subject of the Bunsen method, I ought to mention that in photometry, for the grease spot is sometimes substituted a star of thin paper, sandwiched between thicker paper; that is known as a Leeson disk, and has been much improved by Mr. Dibdin.

Methven proposed to use a slit placed in front of an Argand gas jet as a regulator, if I may call it so, of the quantity of light issuing on to the grease spot. This appears at first sight an admirable arrangement, and it would answer well if the grease spot were always kept at the same distance from the source of light, but when it is moved, an error, though it may be very small, must be introduced. An Argand flame is practically a hollow cylinder of light, of a certain thickness. (Fig. 4.) As you approach the light, the section of the cylinder varies, and consequently the quantity of light falling on the spot must vary beyond what it should do. It may be remarked that putting aside this error, the measurements are made from the slit and not from the source of light, which is a decided advantage. Messrs. Hurter and Driffield have to a large extent got rid of this light and employ a flat flame, of large size, as the source of light, and use a small square aperture in front of the flat side. As the section of such a flame appears to be uniform, the inaccuracy of measurement introduced is done away with. In reference to this it may be interesting to show that in an ordinary flame the light varies in intensity at different points. This can be done well by means of photography, reducing the exposure each

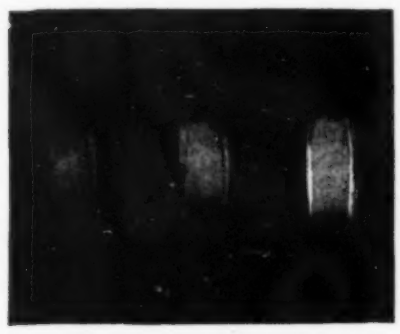


FIG. 5.

time. Fig. 5 is an Argand burner flame, Fig. 6 a batswing, and Fig. 7 an ordinary candle.

It will be seen that in the candle flame we have an almost expected result. The Argand gas is more surprising. The batswing gas is perhaps the best, as it shows that in the wing used the intensity remains almost constant. I think these photographs will demonstrate to you that if the quantity of light to be admitted to a screen is to be determined by an aperture, the burner should be of the batswing type.

Before quitting the subject of photometers, I must introduce to your notice the radial photometer of Dibdin (Fig. 8). The diagram almost explains itself. The object of the photometer is to measure the illumination of a flame in all directions. It will be seen that the arm which carries the light to be tried remains always at the same distance from the screen. The screen itself is so arranged that its surface bisects the angles between the lines joining the two lights and itself—a most necessary thing, when Fig. 3 is taken into consideration.

We have now to turn to the method of judging the

FIG. 6.

equality of light; that is, how the eye can best appreciate the light.

We are told very frequently that the eye can appreciate about the one-sixtieth part in the intensity of light, or, say, 2 per cent. There is a story told of a celebrated witness who, when asked whether such and such a thing was the case, said: "Yes and no." Now if I were asked the question as to whether the above limit was true, I could safely answer in the same terms. First of all let me show you an experiment, which will prove that this limit is both understated and also overstated. I have on this screen a variety of grays between black and white. We can now see them all, and the difference between them. If I turn down the light, a great many of these appear the same tint. If I turn on to them a very strong electric light, those not nearly white, when looked at from where I am, appear white, and it is only when there is considerable black in the shade of tint that they appear gray.

FIG. 7.

As a matter of fact, there is an intensity of light, in which much smaller differences than the one-sixtieth can be perceived. I believe, for my own part, that, when the light is suitable, a difference of nearly one-two-hundredth is recognizable. But it is not necessary that the eye should be so sensitive as the above, so long as proper precautions are taken in balancing the light. If we balance from "too light" and then from "too dark," the mean will be fairly exact, and probably not be far off the truth by a good deal less than 1 per cent. But there is another plan, which is better still, and that is by rapid oscillations in intensity on each side of the true point. This is difficult with many photometers, but not with all. When this plan is adopted, supposing we are using the shadow method, the two shadows appear to wink, and, when exactly balanced, this winking stops. It is curious how, with-

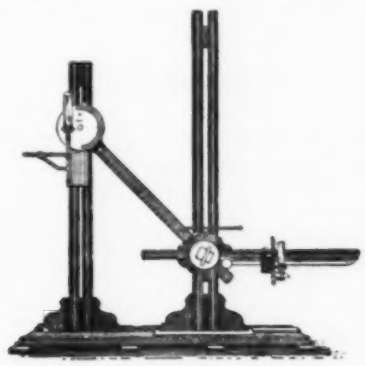


FIG. 8.

out this artifice, readings, which can be proved to be palpably wrong, are made. For instance, when one shadow is intensely darker than another, the eye of the observer will fail to see it, when the alteration is made slowly. If the eye, however, has a rest, by looking away at some black object, the inequality of the shadows will at once be seen. This cannot happen when the method of rapid oscillation is adopted.

What the cause of this may be is not absolutely proved. When the eyes look at two objects (spots or shadows), the images of the two are projected on different parts of the eye, these portions get fatigued, and the longer they are looked at the greater the fatigue. The brightness of the two gets lowered and they gradually approach one another. When the system of oscillation is adopted, though both images are lowered in tone, yet there is a constant brightening and dimming in both, not sufficiently rapid to make each of them practically uniform in a tone midway between the two, but scintillation is produced. We can see how the eyes can be fatigued by a very simple experiment. I will throw a bright patch from the electric light upon the screen, which is also partially illuminated by gas light. If the audience look at it for a few seconds, and keep their eyes fixed on the screen when I cut off the electric light, they will see a dark

FIG. 9.

spot where the bright patch was, and it will appear to travel about as the eye wanders over the screen. This shows that the part of the retina on which the white patch was received is fatigued, and is less sensitive to the feeble gas light illumination with which the screen is illuminated.

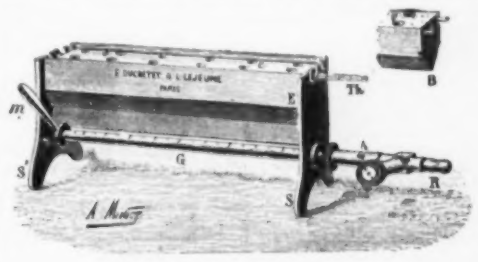
Some very instructive measures of the sensitiveness of the eye to different shades of light can be made by a sector arrangement. Black dots of any size required (in the case in point they have one-eighth of an inch diameter) can be placed on a white disk, as shown. This disk is cut radially from the center, and a black disk is marked out in the figure. The proportion of black and white can be altered at pleasure, and a further slight alteration in the gray produced is made by the dots; the smallest alteration, of course, being when the dot subtends the smallest angle. By this plan the sensitiveness of the eye to any small change in light can at once be found. The sector may be varied between all white to nearly all black. Similarly white dots may be placed on a black disk, a white disk overlapping, and unique measures made. It must be remembered that in all cases the black itself reflects a certain amount (in this case about 4 per cent.) of white light.

THE MEASUREMENT OF FUSING POINT TEMPERATURES.

WHEN the temperature of a solid body is gradually raised by the absorption of heat supplied from an outside source, the units of heat so absorbed can be determined by calculation, provided that the specific heat and mass of the body be known for the range of temperature considered. On increasing the temperature by continued supply of heat units, an action which may be described as an unlocking of the molecules takes place, and a further addition of heat gradually will cause a change of state from solid to liquid at a moment called the point of liquefaction. At this point we have to consider the energy absorbed to cause the change of physical being of the body, and this is given as "the latent heat of liquefaction."

The point of fusion varies with different substances, but for any given material it is a constant quantity, provided that all other conditions be the same. At first sight the determination of the fusing point of a given substance appears to be a very simple and easy matter, but it has been found that if absolute accuracy be aimed at, this simplicity is more assumed than real. Where a very small margin for error is allowed for personal and instrumental deficiencies, the determination is by no means an easy one.

In the majority of cases one is content to place the solid matter, whose fusing point it is required to determine, in a glass tube with a conical end. This may be dipped into a bath of mercury, the temperature of the bath being raised very slowly, while the conical portion of the tube, in which the solid matter is placed,



is closely watched, so as to determine the action point at which fusion occurs.

A delicate thermometer, whose scale has been calibrated in mercury prior to the experiment, may be used to indicate the temperature at which change of physical state takes place, but it is necessary to allow for the heat lost by that portion of the mercurial column which is exposed to the air. A correction factor can be obtained and applied to the observed result to correct for this. The correction becomes considerable for high temperatures, and is always more or less uncertain, and is sufficient to render the results inaccurate to some extent if it be not taken into consideration. This is shown by the divergence between the melting points given by different observers for the same material, some of which differ among themselves no less than 10° C.

The apparatus of Maquenne, which we illustrate herewith, was made by MM. Ducretet and Lejeune, of Paris, was submitted in 1887 to the Chemical Society of Paris, and is designed to indicate the exact fusing points of materials with the application of second and third corrective terms to the readings taken by observation. The apparatus consists essentially of a prismatic block, B, as shown in the figure, of red copper. This is drilled longitudinally throughout its length, a little below its upper surface, to form a chamber in which to place the thermometer, Th., the latter being one giving very exact readings. The bulb of the thermometer gives an exact indication of the temperature of the metal throughout its length.

The block, B, rests on a support formed of two vertical plates of red copper which protect the gas flame underneath from draughts in a direction endwise. The plates are secured to the supports, SS, upon which the whole is mounted. A gas burner, G, is used to heat the whole mass, slowly or rapidly, as may be required, regulation being provided by the stopcock, R. The temperature which can be obtained is 400° C., and, owing to the high thermic conductivity of the block, B, the temperature is maintained uniformly through the length of the block, so that it is not necessary to apply any correction for a drop in temperature between the thermometer scale and its bulk.

The substance to be tested is placed in very small quantities in the small cups, C, the mouths of which are at the surface of the block, B. The point of fusion is observed with the greatest ease, and this is also the case for the point of solidification. In use two cups may be taken and filled with samples of two materials which are supposed to be identical: by this means an immediate comparison may be made. For temperatures below 100° C. it is best to heat up the apparatus slowly, and with a small number of flames. The jets of gas issuing from the burner may be controlled by the handle, m, and the desired result so obtained, while the rate of flow of gas can be adjusted by regulating R, so as to obtain a minimum of heating power. The arrangement by which a sensitive adjustment can be obtained is due to Mons. Bertrand.

The same apparatus can be used to determine the melting points of fats or solid lubricants, as well as the temperature at which fusible metals liquefy. Fusible metals, such as lead, change their form at the temperature of fusion. To determine the exact point,

it is sufficient to touch the substance in a cup, c, with a silver point, when a delicate sense of touch will give the exact moment when plasticity is reached. We may mention, admirable as the apparatus as a whole seems to be, that it is probable that care will have to be exercised that no substance be tested which at high temperatures will act on, or be acted on, by the copper. Some experiments we made some years ago showed that, if chemical action take place, the true melting point will be obscured by the secondary effects of decomposition.—Industries.

[From Popular Astronomy.]

MARS.

By Percival Lowell.

The editor of Popular Astronomy has asked me to write a series of articles on what is now known of Mars, together with what may become known about him, this autumn, during the coming opposition. As introductory, I will preface a few words to the reader. One thing is, given the facts about our neighbor world, a person can form a better opinion as to what they disclose than he might, in his modesty, suspect. For the problems which will present themselves for solution are questions of general physics in the first place, and questions of probability in the second. Especially is it a mistake to suppose that professional observers alone are entitled to an opinion on the subject. As a rule the professional observer is not much of a mathematician nor of a physicist, except of the journeyman kind, and though he is an expert in collecting data, he is often far from an expert in interpreting the same; as some of the comic theories advanced on the subject now before us seem to demonstrate. It may be well to remind the reader that neither Newton, Laplace, nor Gauss nor Helmholtz, nor Lord Kelvin were observers. An observer may be an excellently good reasoner, just as he may have blue eyes, or he may be a singularly poor one.

A second point is that no amateur need despair of getting interesting observations because of the relative smallness of his object glass. There is much popular misapprehension on this point. In matters of planetary detail size of aperture is not the all-essential thing it is tacitly taken to be. There are three factors that enter into any observation: the observer, the atmosphere, and the instrument; and in matters of planetary detail both eye and air are more important than aperture. For an explanation why this is so optically, I will refer the reader to an article of mine in the August Astronomy and Astro-Physics, and to other articles which will appear later in the same periodical. Proof of this fact is afforded everywhere by the history of astronomical research. That Schiaparelli made his surprising discoveries on Mars with only an 8½ inch glass, that they were at first ridiculed by some, and that they had to wait years for larger glasses to make them visible to common eyes, are enough to hearten any amateur.

Next to the man is the atmosphere through which he looks. A large glass in poor air will not show what a small glass will in good air.

Once in about every twenty-six and a third months a strange and startling visitant makes his appearance upon our midnight skies. To one who has not kept track of what the Greeks so suggestively called "the wanderers" (*πλάνητες*) this star will seem something of a portent. Outshining Sirius, dwarfing all other lights in those depths of space except the giant Jupiter himself, the stranger appears yet more fateful for being of a flaming red. This star is Mars, the planet of war of the ancients, which the earth has once more overtaken in her swifter circling round the sun.

But just as a soldier, sheriff, or judge will thaw in the warmth of intimacy into something surprisingly human, so science has touched with satire the Martian superstition of olden times. Increasing acquaintance has now shown us that of the whole company of heaven, the dread wanderer of war is probably the most peaceful body we know. Even in the heyday of his jeunesse orageuse he was in all likelihood not extravagantly wild, and he has now long since lapsed into the quiet dotage of advancing years.

Disillusionment begins by actually daring to attack his hue. By means of the deadly parallel his flaming red is found to be perceptibly yellower than an ordinary gas jet—a sad surprise to any one who will take the trouble to hold a candle to his face. Some slight consolation, however, returns with the telescope, for there he shows ruddier than to the naked eye.

Now there are two points of view from which we may regard any planet—as a member of our solar family and as a world in itself. It is principally in his second aspect that these papers will deal with Mars. For his relation to the rest of the system of which he forms a part is pretty well determined. It is his physical condition which still remains doubtful and to which modern astronomy is now especially directing its attention. His family standing is not unconnected with his individual state, inasmuch as each planet is busily engaged all the time in pulling all the others out of place; in consequence, each is slowly deforming the others' orbits and by so doing changing the times and characters of the seasons of their respective years, tending to produce glacial epochs and other interesting phenomena as the result.

But this relation of one planet to his fellows is chiefly interesting to us in the present connection not for what it effects, but for what it allows us to infer. For the actual changes are brought about very slowly and do not sensibly affect the planet from one century to the next. On the other hand, a knowledge of the relative conditions under which any planet performs his circuit about the sun, as compared with those under which our own earth makes her yearly round, is highly important to any understanding by us of that planet's physical state.

But instead of beginning with a more or less disconnected array of figures about Mars, I shall wait to let these introduce themselves in the places where they naturally belong, and shall take up a study of the planet where it really began at the eye end of the telescope, thus giving the reader in this introductory paper some slight idea of what Mars looks like

To start with, then, we will begin with the first two drawings worthy of the name ever made of the planet by man.

Now it would be safe to wager a small fortune that no one, not versed in the subject, would instantly recognize the pair for pictures of one and the same Martian marking. Yet such they are. The one was made by Huyghens in 1659, the other by Hooke in 1666, and both undoubtedly represent what is known as the Hour Glass Sea, the most distinctive and in a way the most important feature upon the planet. To explain the palpable discrepancy between its two delineations, we are led to consider the relative positions in space in which Mars and the earth may find themselves.

The orbits of all the planets are approximately ellipses; if each planet were not perturbed by all the others, its orbit would be perfectly elliptical. This is

Fig. 1.—DRAWINGS OF MARS BY HUYGHENS.
Nov. 28, 1659, at 7 P. M.
(Reproduced from Flammarion.)

no fortuitous coincidence, for given the law of gravity, it could not possibly be otherwise. The proof of this is one of the prettiest deductions in dynamics. To Kepler we owe the discovery that the planets move in ellipses, and to Newton the proof that this shows them to obey a central attractive force directed toward the sun and varying inversely as the square of the distance from him. But these ellipses show something more. They show that although the sun controls his family now, something other than the present sun set the various members of it going originally. For had any of them not possessed some tangential motion to start with, at the time its individual existence began, it would simply have traveled straight into the sun, and

Fig. 2.—DRAWINGS OF MARS BY HOOKE.
March 13, 1666, at 12:40 A. M.
(Reproduced from Flammarion.)

thenceforward not traveled any more. The present elliptical orbits of the planets carry, therefore, in their very form proof of the truth of something like the nebular hypothesis of Laplace.

Now these elliptical orbits are chiefly interesting to us with regard to the subject in hand because they all differ in eccentricity, that is in the amount they deviate from a circle, which is but a special form of the ellipse. That of the earth is fairly circular, a paltry 3,000,000 of miles summing up the difference between our nearest approach to the sun and our farthest recession from him. But with Mars this is not the case; at times he is 26,000,000 of miles farther off from that luminary than he is at others. Now since the earth

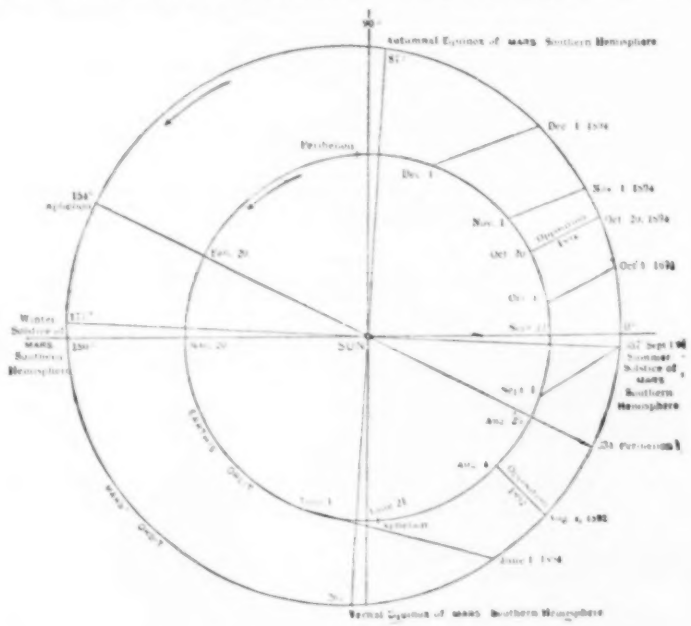


Fig. 3.—ORBITS OF MARS AND THE EARTH FOR THE OPPOSITION OF 1894.

and Mars take different periods of time to complete the circuits of their respective orbits, it will at once be seen that this brings them into conjunction at very varying distances apart. A diagram will make this clearer.

Now it so happens that the point of nearest approach between the orbits of the two planets lies opposite that part of the earth's orbit which she reaches on August 25 and the farthest similarly opposite February 20; so that the most favorable oppositions always take place in late summer or early autumn, while the least favorable take place in the spring.

It also happens that the Martian summer solstice of the southern hemisphere occurs only 23° distant from perihelion point. This makes it that in the most favorable oppositions Mars shows us chiefly his southern hemisphere; in the more distant ones his northern.

We are now in a position to reconcile the two drawings of Huyghens and of Hooke. For the one of these was made at the time of the summer solstice of the Martian southern hemisphere (like all astronomical drawings, both are upside down), while the other was made during the winter solstice of the same hemisphere. The latter is also properly represented the smaller, for then the planet was much further off.

Now, innocent as it looks, Huyghens' drawing is perhaps the most important one of Mars that has ever been made. For from his observations of the spot it depicts, he was able to prove that Mars rotates on his own axis and to determine the time of that rotation. In other words, he first learned the length of the Martian day.

The importance of these earliest pictures of Mars has not lapsed with the lapse of time. By comparing Hooke's drawings and another by Huyghens in 1672 with modern ones, has been deduced a very accurate determination of the length of this Martian day (its sidereal day), a determination accurate to a tenth of a second. It amounts to 24h. 37m. 22·71s. (Proctor) or about 41m. longer than our own day.

We owe our knowledge of Martian timekeeping then to the distinctive marking known as the Hour Glass Sea. Its name was given it from its general appearance to that once familiar but now obsolete article. But, interestingly enough, it has acquired a title to the name in a yet more becoming manner, for it is, as we have just seen, by this hour glass marking upon the planet's face that we have learned to tell the Martian hours across so many millions of miles of intervening space.

There is, then, as Flammarion well says, a poetic fitness in keeping up this early appellative, instead of changing it to Syrtis Major, which Schiaparelli would have us do.

Before we part company with the orbits to pass on to other features of the disk, one more point connected with them is worth notice. If we draw a line from the sun to the center of Mars and pass a plane through the planet perpendicular to this line and to the plane of his orbit, this plane will divide the illumined half of him from the unillumined half. If now we draw another line from any point of the earth's orbit to Mars' center and pass a plane similarly perpendicular to that, it will cut off the hemisphere we see at any moment from the one we do not. As the two lines do not in general coincide, it will appear that in certain positions, in fact, in all but two, Mars must present to us a face partly steeped in daylight, partly shrouded in night; in short, that he shows gibbous like the moon when she is between the half and the full. By drawing lines to more than one position occupied by the earth, it will be seen that this phase reaches a maximum when the earth as viewed from Mars is at extreme elongation from the sun, and that the amount of the phase at such time exactly equals the number of degrees of this elongation. For example, on the sixteenth of last June the lacking lune amounted to 47°, that is, the earth was then evening star upon the Martian twilight skies and seemed to him 47° off from the sun—about what Venus seems to us at her extreme elongation. It was some time after the invention of the telescope before astronomers began to see anything to speak of in Mars. More or less doubtful spots, however, were made out, and next to the discovery that the disk presented spots came the recognition of two curious white caps covering the planet's poles. These were sometimes seen together, but more commonly not, owing to the tilt of the planet's axis.

But about whichever pole happened to be bowed toward the earth, the brilliant polar cap soon became under increasing optical aid a most conspicuous feature. Furthermore, it was observed to vary with the Martian seasons. Through the winter of the hemisphere to which it belonged it was found to be very large, extending to about 45° down from the pole, that is, it was 90° across. With the advent of spring it began to shrink, till some two months and a half after the summer solstice it had dwindled to nearly nothing. Then with the deepening autumn it started once more to grow. It presented, therefore, almost precisely the

same appearance viewed from the earth that the earth's polar snows would viewed from Mars. It was in consequence taken to be really a polar snow cap. The evidence that this is the fact is steadily accumulating, so that now, though we do not know the exact character of the snow, that it is snow in the widest meaning of the term is practically beyond a doubt. The evidence will be adduced when we come later to study the phenomenon in detail.

The rest of the disk was next found to be diversified by dark and light markings. The light ones were of an orange, the dark of a gray or greenish tint, and the two were accordingly supposed to be land and water respectively. As the disk came to be better and better seen under increasing powers, it was evident that the proportion between the two was quite different from what it is on earth. Instead of the water surface being largely in excess of the land, it appeared that the land area was in excess of the water.

The assumption that the light and dark markings represent land and water is doubtless largely correct. That the so-called land is land is next to certain. In the first place, all the details of observation go to prove that it is such; secondly, the antecedent probabilities point in the same direction; and thirdly, no theory worth serious consideration has ever been advanced to show that it is not. That the "seas" are water is more doubtful. But the best evidence at present is that a part of the dark markings are really due to water, while a part of them are not, betokening probably vegetation of some sort or other, as will appear later.

That these markings are essentially permanent is now beyond question. That is, unlike the markings on Jupiter and Saturn, those on Mars belong not to a cloud envelope, but to the real surface of the planet. Yet as late as 1839 Madler doubted this after having held the opposite view. Indeed, the history of doubt about Mars is both humorous and instructive. It is really remarkable how correct first impressions have proved and how erroneous second thoughts; which means, of course, that Mars is much more like our earth than we are altogether willing to admit.

To the ever "eagle-eyed" Dawes we owe much in the way of Martian topography, as of most other astronomical matters. His observations in the early sixties made the basis of a chart of the planet by Proctor, the first important chart made. It was an admirable one in its day, and although antiquated now, may still be used advantageously for the general identification of the planet's topography. Later, when influenced by Schiaparelli's growing importance, he published a sort of compromise new edition of his chart—the child of the closet, not of the observatory—he made a bad botch out of an originally good business; for his new chart is neither good Dawes nor good Schiaparelli, but something Mars never looked like to any mortal eye.

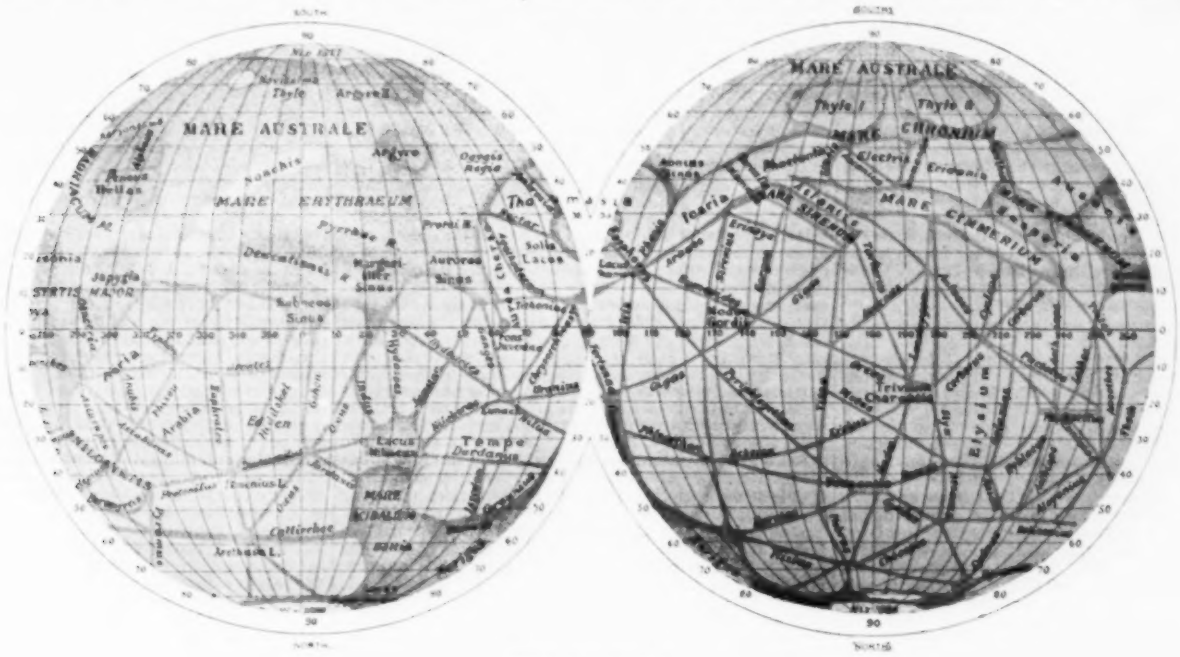
But of what we may call the middle period of our knowledge of Mars' markings, the admirably artistic drawings of Green in 1877 are the most typical, as they were also the last of any account. For at the very moment that Green was thus unconsciously embalming the old areography at Madeira, Schiaparelli, at Milan, was inaugurating the new.

It was in 1877 that Schiaparelli first saw his now world famous canalli, which have been generally translated canals and then generally begrudged the quality which the name implies. But it looks now as if this were going to prove another instance of the virtue of first thoughts over second ones. Of this more anon; our present purpose being merely topographical.

Schiaparelli made several charts of the planet, his last one being in 1888. I have here reproduced it with a few additional names from his earlier ones from the copy given by Flammarion in his thesaurus entitled "La Planete Mars." The map labors, of course, under the general difficulty inherent in the attempt to represent an undevelopable surface upon a flat one; the result here being that not a single piece of the chart resembles the actual presentation of any part of the planet at any time. If the observer, however, will take the trouble to plot the positions of the several markings upon a plain globe suitably divided into meridians and parallels and view that, he will, by tilting it properly, get a very fair idea of the surface the planet presents at any given epoch.

Throughout my subsequent papers I shall refer to this map constantly as to any similar geographical map of our own earth. Before the series is finished, however, I shall present a later one from observations at this observatory.

Lowell Observatory, August, 1894.



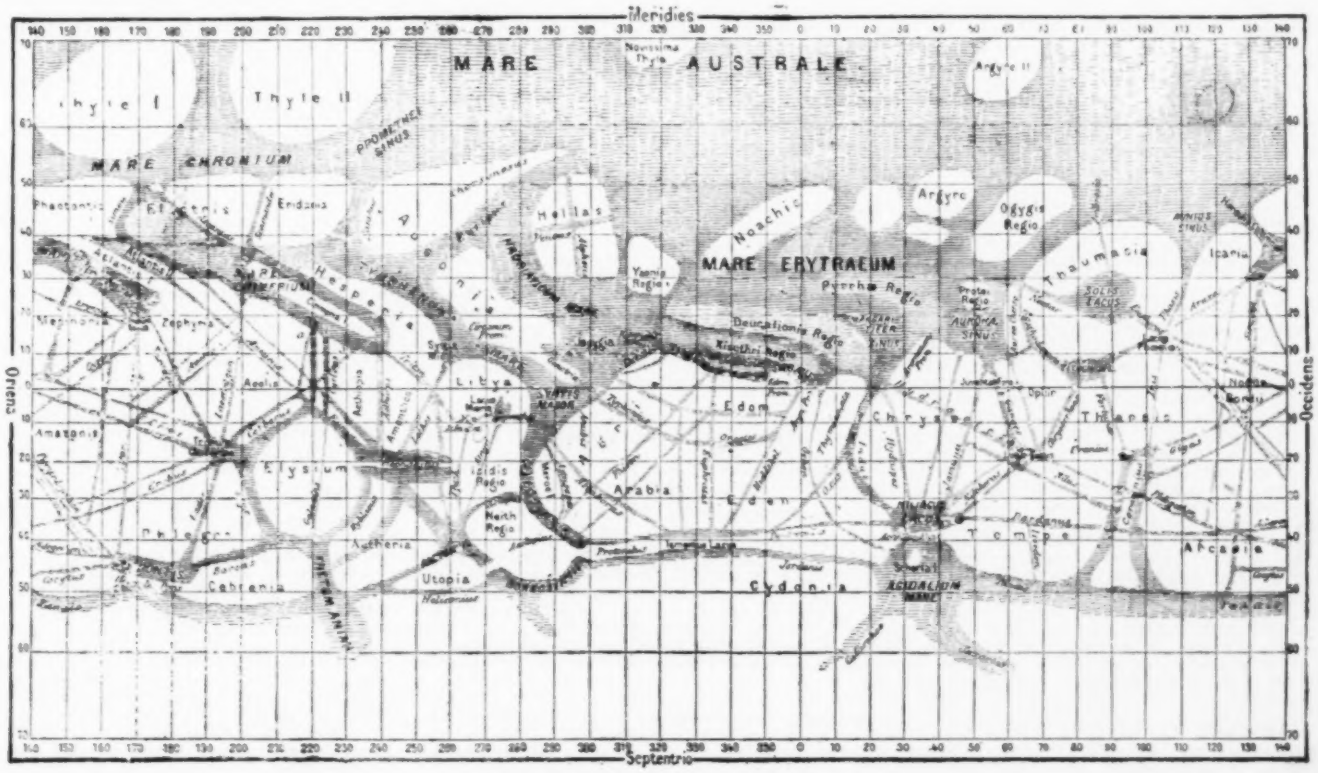
MAP OF MARS.

THE LOWELL OBSERVATORY—OBSERVATIONS OF THE PLANET MARS DURING AUGUST.

THE greater portion of the work of the Lowell Observatory during the month of August was routine, and but few items seem to be of sufficient immediate popular interest to merit especial note. Throughout the month the projections and notches in the Terminator were systematically observed by Mr. Douglass with a view to an elevation map. On August 19, Mr. Douglass saw a remarkable notch near the position of Nix Olympica. On August 16, a plateau projection was seen by Pickering, who saw another on August 24 in Phaetontis. On August 29 it became evident that the Terminator remained persistently flattened when the seas were divided by it.

[A plateau projection is one with a long flat top, indicating a considerable extent of elevated surface. The flattening of the Terminator on the seas indicates that these areas are lower in level than the general surface of Mars.—EDS.]

During the month the canals were seen constantly to better advantage, and new ones, not seen before at any opposition, were found quite often. On August 14, new canals were seen by Douglass in Œnotria at right angles to each other; on August 16, three new canals in Æthiopus by Pickering; on August 19, several new ones between Mare Cimmerium and Trivium Charon-



A MAP OF THE PLANET MARS.

tis by Douglass; on August 24, several new ones near the Lake of the Sun by Pickering; and on August 29, one from Mare Sirenum to Cerannius by Lowell.

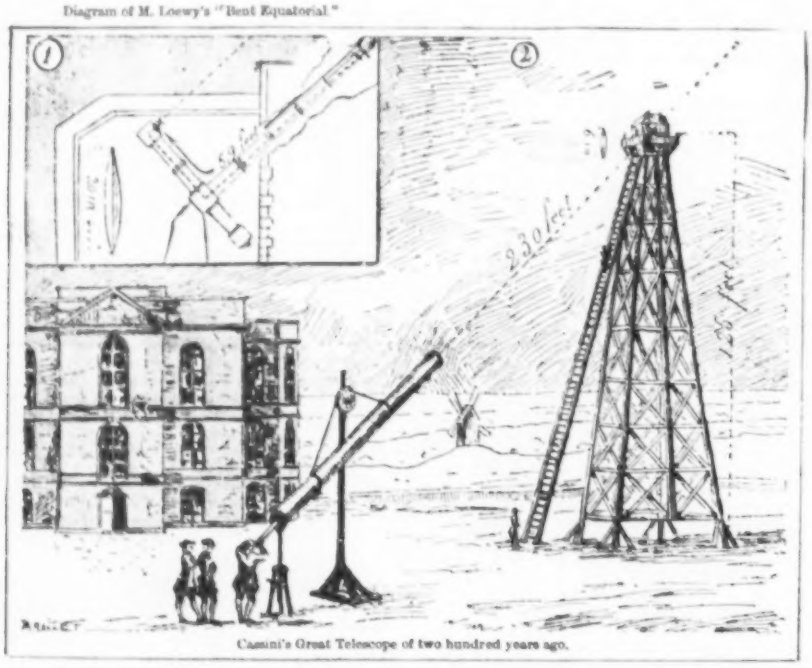
The small spots called lakes were being constantly found, new ones being seen, two on August 16 by Pickering, one on August 24 by the same, and one by Lowell on August 29. On August 8, a darker spot was seen by Douglass in the Sabæus Sinus; on August 27, certain whitish spots were seen on the northern hemisphere of the planet; and on August 7 the mountains indicated by the star like points were seen as a separate snow island, detached from the Polar cap.

[Although not included in the work of the month of August, it is of interest here to add that the satellites of Mars, Deimos and Phobos, were first seen at the Lowell Observatory on September 10. The observations of September 15 show that the diagram given in the Nautical Almanac is wrong in its details, especially the direction of the orbital motions, for which the arrows should be reversed. This is a matter of some importance, since any one using the diagram is likely to be misled as to the position relative to the planet in which to look for the satellites.—Eds.]—Boston Commonwealth.

THE PARIS OBSERVATORY—THE OLDEST AND NEWEST TELESCOPES.

A correspondent of the Daily Graphic, London, says: Through the courtesy of M. Loewy, the President of the French Academy of Sciences, we were able to publish an account of his great "bent equatorial," and we expressed the hope that the efficiency which the earliest tests to which it had been subjected seemed to promise for the new instrument would be attained in its actual working. That hope has been fully realized. The various difficulties which developed themselves in its use have one by one been overcome, and M. Loewy has been able to exhibit to the French Academy at its meeting of July 23 last a number of photographs of the moon taken with this new refractor, which for beauty, definition and richness of detail leave nothing to be desired.

Diagram of M. Loewy's "Bent Equatorial."



Cassini's Great Telescope of two hundred years ago.

THE OLDEST AND NEWEST TELESCOPES OF THE PARIS OBSERVATORY.

THE FOCUS OF THE NEW INSTRUMENT.

An important feature of these photographs is the scale upon which they are taken. The image of the moon in the focus of the instrument is nearly seven inches in diameter, and it is easy, by the use of an enlarging lens, to obtain photographs at the telescope itself on a scale of three feet or forty inches to the diameter to the moon. This ample scale is secured by the great length of focus which the telescope possesses, namely, fifty-nine feet. This is greater than the focal length of the great Lick refractor, and is more than double that of the new 28 inch telescope at Greenwich.

TWO HUNDRED YEARS AGO.

This is by no means the first time that telescopes of great focal length have been dealt with at the Paris Observatory. Two hundred years ago the then astronomer royal of France, Cassini, succeeded in manipulating an instrument of nearly four times the focal length of that which the ingenuity of M. Loewy and the optical skill of the Brothers Henry have brought to such perfection. There was at that time a special necessity for telescopes of these extravagant lengths. The small field of view of the telescope in the form in which Galileo used it, namely, a convex object glass with a concave eye lens, caused it to be early discarded for the "astronomical telescope," where convex lenses were used for the eyepiece. But a great drawback was experienced, for the chromatic and spherical aberrations were much more serious than in the Galilean telescope. In other words, the different colored rays of light did not come together at one focus, nor did the rays which passed through the center of the object glass come to the same focus as those which passed through it near its circumference.

CASSINI'S GREAT TELESCOPE.

These drawbacks were much diminished by using an object glass of longer focus, which had the further advantage of giving a larger image, so that a lower magnifying power sufficed for the eyepiece, and Cassini especially distinguished himself by the enormous length of some of the telescopes which he employed. The greatest of these, which is represented in Fig. 2 of our illustration, copied by our artist from an original engraving discovered in the Paris National Library, had a focal length of no less than 230 feet, though the object glass itself was only six inches in diameter. It would have been impossible for the astronomer to have utilized this lens had he not succeeded in obtaining from Louis XIV. permission to use a wooden tower, 150 feet in height, which had been used for the Versailles water works. The object glass was mounted on the top of this tower, but no continuous tube united it with the eyepiece. The latter was inserted in a short tube, in order to keep out scattered light, and attached to a movable stand placed on the ground.

THE OLD AND THE NEW: A COMPARISON.

It is hardly possible to conceive the difficulties and annoyances which observation with so unwieldy and disconnected an instrument involved. The difficulty of getting object glass and eyepiece to truly point in the same direction, of bringing the planet or star into the field of view and of keeping it there when once caught sight of, must have been immense, and work must have been subject to the most tantalizing and exasperating interruptions. Yet, in spite of these difficulties, Cassini succeeded in discovering the great division in Saturn's ring and four of his satellites. It would require an exceedingly fine modern telescope, with the same light-gathering power, to show more satellites than Cassini saw. Such was the old long-focus telescope—the object glass partially fixed, the eyepiece movable, and moved by hand, the observer wandering about in the open, exposed to every wind, and doing his work under difficulties and discouragements beyond conception. What a change to the new form! Here the observer sits at ease in his chamber. His eyepiece, a fixture, stands at a convenient angle on his table. His work requires no more exposure and exertion than that of a microscopist. His object glass moves, but he need exert no effort with regard to it. His imperturbable clock keeps the lens turned truly toward the star he is watching, so that it remains in the center of his field of view, if necessary, from its rising to its setting.

ADVANTAGES OF THE "BENT EQUATORIAL."

This wonderful convenience is secured by the intervention of two plane mirrors. The object glass, which can turn about an axis so as to point to a star at any distance from the pole, is carried by one arm of the telescope in a plane parallel to the equator. A mirror just behind the object glass reflects the light into that plane. A second mirror at the "elbow" of the telescope reflects the light up to the eyepiece along a line which is parallel to the polar axis of the earth, and which is thus the same for every star in the sky. Thus, as Fig. 1 of our illustration will show, the greater part of the length of the telescope is fixed and securely sheltered. This is an advantage not inferior to the advantage of comfort to the observer, and it permits an increase in the focal length, with all its consequent benefits, without any sacrifice of stability or increase in the difficulty of manipulation. A further advantage, and one especially felt in the case of a large instrument, is that no dome is required.

CONSTRUCTORS, OLD AND NEW.

Which is most to be admired: the patience and skill of old Cassini, who made such great discoveries with so inconvenient a telescope, or the patience and ingenuity of M. Loewy and his helpers, the Brothers Henry, who devised so ingenious an instrument and overcame the numberless difficulties involved in its construction? Perhaps the latter, for other observatories besides that of Paris will profit by their labors, and Algiers, Besancon, Lyons, Nice and Vienna will be equipped with similar instruments. The difficulties of the old long-focus telescope were avoided by English astronomers by the construction of better instruments of much smaller size. Newton, Short and Herschel abandoned refractors and constructed reflectors of far greater efficiency, as well as far greater convenience, than the "aerial" telescopes of Huyghens and Cassini.

Chester, Moor, Hall and Dollond, by making the object glass of two lenses, succeeded in constructing the achromatic refractor and in overcoming the worst of the evils which the long-focus lens was meant to avoid. And to-day Mr. Dennis Taylor claims to have carried the solution of the problem a great way further still, and to have made a triple object glass free from the color error which still attaches to the best double object glasses, and which is actually and not merely in conventional language, "achromatic."

INSECT SECRETIONS.

By E. A. Butler, B.A., B.Sc.

Among butterflies and moths, the exciting moment when the most wonderful change in their whole history takes place—the moment when they throw aside the death-like torpor of the limbless chrysalis and take on, to all appearances suddenly, a complete locomotive equipment consisting of six legs and four wings—is an occasion which, in consequence of its exceptional requirements, is fruitful in the production of characteristic liquids. When a chrysalis is inclosed in a cocoon, it is obvious that some substance must be produced by the newly emerging insect, which it may use as a means of escaping from its enveloping shroud of silk. It has no biting jaws, as it had just before it entered on the pupa stage, so that gnawing its way through is altogether out of the question, and it must make its escape by using some solvent which will chemically affect the silk, and either loosen its component threads at the spot where the exit is to be made, or absolutely dissolve them. In our articles on "Curious Cocoons," we have already pointed out that it has recently been discovered that, in one instance at least, this solvent has the remarkable characteristic of being a strong caustic alkali—none other, in fact, than potash itself. We refer to the instance of the puss moth, whose exceptionally hard cocoon necessitates an equally powerful solvent. That an alkaline fluid was produced by this insect on its emergence was indeed noticed nearly fifty years ago, but its exact nature was not determined until quite recently. Analogy would lead us to conclude that a liquid of somewhat similar nature, or at any rate of similarly corrosive action, must be produced by other moths which enjoy the shelter of closed cocoons during their period of lethargy.

Those who have kept caterpillars, and watched the changes through which they pass, are familiar with the fact that a newly emerged butterfly or moth discharges a quantity of a reddish fluid from its digestive tube, so that the ground in the immediate neighborhood of such an emergence, and the various objects around, including often the old chrysalis shell, become bespattered with drops of colored liquid, which soon dry up and leave behind a reddish or orange powdery deposit. This liquid is of an acid character, since it reddens blue litmus paper when placed upon it. It is often shot out in considerable quantity and with great force, especially when the insect is disturbed before it has become properly prepared for its new style of life.

Not only does this discharge take place when a chrysalis becomes a perfect insect, but a similar incident often occurs when the caterpillar becomes a pupa. The contents of the alimentary canal are then voided in a semi-fluid condition, though under ordinary circumstances the excrement is compact, and comparatively dry and hard. In the case of the emperor moth (Saturnia carpini), Mr. Bateson has made a careful examination of this discharge, specially with a view of determining its relation to the color of the cocoon. While still contained within the alimentary canal the liquid is green, but shortly after being ejected it becomes reddish brown. Microscopically examined, it is seen to consist of a colored liquid containing partially digested food. If it be filtered through blotting paper, a clear green liquid is obtained, which turns reddish-brown in the course of a few minutes. This is no doubt a chemical change due to oxidation, resulting from exposure to the air, as the following experiments tend to prove. If a little be placed on a glass plate, the outer layer may be seen to have changed color, while the lower part, being out of contact with the air, still remains green. If again the liquid be placed in a tube, and then shaken up with air, the darkening process is accelerated. Yellow nitric acid, a body which easily yields up oxygen, destroys the green color at once, and turns the liquid reddish-brown. The question whether this substance is a true secretion or merely a product of the digestion of the food, is not so easy to determine, but that the latter is its true source seems probable from the fact that no such coloring matter can be discovered in the walls of the intestine, though one would expect to find it there if it were a true secretion from glands on the walls.

But though these colored liquids ejected by caterpillars just before pupation may not really be connected with any special secretory organs, there is an instance of a remarkable product which has been traced back to a special part of the alimentary canal, and is thus shown to be of the nature of a secretion. The product referred to is a powder formed by the caterpillar of the lackey moth (Clisiocampa neustria), a well-known flabby creature, striped with reddish, orange and blue, and often found abundantly on whitethorn hedges. This caterpillar fashions for itself a delicate white silken cocoon, of loose and semi-transparent texture. The part immediately surrounding the insect is more compact than the rest, but even that remains sufficiently thin for the outline of the chrysalis to be faintly traced through it. When the caterpillar has completed its task, it discharges from the end of the alimentary canal a quantity of a pale yellow powder, which looks a good deal like flowers of sulphur. This powder, lodging in the meshes of the silk, of course renders the cocoon a good deal more opaque, and thus may perhaps be a source of protection to the insect.

Mr. Poulton recently examined this powder chemically and microscopically, and found that it consisted of minute crystals of carbonate of lime. Dissections of the caterpillars showed that the ultimate source of the powder was the malpighian tubules, the long thin tubes that open into the intestine just behind its junction with the stomach. It is, of course, initially obtained from the food, and apparently accumulates in

the tubules till the end of the feeding life, when it is got rid of and made to subserve a possibly useful function in giving greater opacity to the cocoon. This would be of little avail if the creature remained in the chrysalis condition throughout the winter, for the winds and storms of that season would very soon shake all the powder out. But as the insect remains a chrysalis only for a very short time, the obscuration caused by the powder may perhaps be of some slight advantage to it.

Like the skunk among mammals, many insects are distinguished for the strong odor that attends them, and that usually proceeds from fluids which they secrete. In a few instances the odor is agreeable to the human olfactory sense, but generally it is quite the reverse. These odors may in some cases be a means of sexual attraction, and in others the liquids which produce them may cause the insects to become nauseous and unpalatable, and so protect them from their enemies. But it would be unsafe to conclude that scents which are agreeable to human beings are also necessarily a source of attraction to the lower animals, and in fact often the very reverse is the case, for many insects are strongly attracted by decaying matter, which to us smells most foully, and if this be so with what we call evil scents, the same may be true of other kinds. It is not, therefore, a legitimate inference that sweet scents are always possessed by insects as a means of attraction, but that evil odors are a means of protection. But, nevertheless, it may well be the case that the substance which yields the odor may be of such an irritating nature as to make both fragrant and malodorous insects unpalatable.

Two orders of insects are particularly noteworthy for the odors that attend them—the Hemiptera, in one division of which, viz., the Heteroptera, or dissimilar winged bugs, the majority are supplied with a more or less penetrating and disagreeable smell, and the Coleoptera, or beetles, a good many members of which exhale odors, agreeable or otherwise. Outside of these two orders we only meet with occasional instances of odoriferous insects, such as the cockroaches among the Orthoptera, the lacewing flies among the Neuroptera, and the caterpillar of the goat moth among the Lepidoptera. Mr. Robson thinks that the female swifts, which are nearly related to the goat moth, also have the power of exhaling a faint odor which is attractive to their mates, and that the fluttering of their wings which takes place while they are waiting for a partner helps to disseminate the odor.

Among the Hemiptera-Heteroptera, or bugs, there is a wonderful uniformity about the nature of the scent, as well as of the organs by which it is secreted. In almost every instance among the scores of odoriferous species we possess in this country, the odor resembles that of the bedbug, so that even in this respect there is a family likeness which enables the entomologist at once to refer them to their proper order. As a rule, the larger the insect the more powerful the scent, but that is not universally the case, and among the more delicately constructed species, irrespective of size, the smell is often so feeble as to be practically imperceptible to human sensibilities, though of course it does not follow that it is imperceptible to the more acute senses of the insects themselves. The glands by which the fluid is secreted lie on the under side in the central line of the body, and open between the third pair of legs. The form of the orifice and its surroundings varies in the different species, so that it can sometimes be used for classificatory purposes.

The larger, hard-bodied bugs, whose curious shape has gained for them the popular name of "bishops' miters," often smell very strongly, and so penetrating and persistent is the odor that if the substance stains the fingers, the odor is difficult to eradicate, and clings to them even after washing. If after touching them the finger be applied to the tongue, a burning and very irritating sensation is felt. Most of these larger species are not very common with us; they are met with on trees and bushes of different kinds, and are to some extent indifferent as to diet, feeding on the sap of trees or the blood of insects. As they do not occur in large numbers together, their very strong scent is hardly noticed until one comes within two or three feet of them, but then it is found to be very powerful, and if the entomologist happens to have included one of them in his net as the result of sweeping among long herbage, he is sure to be made acquainted with the fact by his nose, even if his eyes are not acute enough to single out the offender at once from among the rest of his captures. The smell of the bedbug is also peculiarly nauseous, though no doubt our dislike of the scent is in this case accentuated by the knowledge of the uncleanly conditions which are indicated by the presence of the insect. But the worst offender in the whole order is a field species which is often to be met with in profusion among grasses and other long herbage. It is called Leptopterna dolobrata; the male is a very handsome insect, and differs a good deal from the female. It is long and narrow, very variable in depth of color, but with the foreparts yellow marked with longitudinal black bands, and the upper wings orange variegated with dark streaks. The female is much paler, being greenish yellow, and rarely has her wings fully developed. The scent of this insect is most sickening, especially that of the female, and I have passed by places where the air has been strongly impregnated with the smell, though the insects were not nearer than ten or twelve feet off, and many of them much further than that. It is hardly likely that an insect so nauseous can have many enemies.

The evil repute of this order of insects is to some extent redeemed by one species, a sand and heath loving creature and no very distant relation of the bedbug itself. This insect (Coranus subapterus) is very elegantly marked with a cool gray, and smells strongly with a fragrance which reminds one of pears. It is exceedingly well protected by its great similarity in color to its surroundings, so that possibly the smell in this case may be a guide to its mates as to its whereabouts.

Among the Coleoptera, or beetles, there are species equally renowned for their scent. The beautiful green tiger beetles which are such attractive adornments of sunny bank in early summer exhale when captured a powerful and very agreeable odor, something like that of sweet brier. Considering that the insects are carnivorous, this is perhaps hardly what was to be expected. That scents such as this are indeed independent of the nature of the food is shown again in the musk beetle, a very large dark green insect with extremely long antennæ. The smell of this creature is not unlike that of the tiger beetle, and equally agreeable, but its food is totally different, for the larva is an inhabitant of tree trunks, the solid wood of which forms its daily diet. Thus we have a predaceous beetle and a wood feeder producing similar agreeable scents, while other members of the family to which the musk beetle belongs, though of quite similar habits, are devoid of smell altogether.

In all the cases already noted the fluid secreted is so extremely volatile that it is never seen to issue from the insect, and its presence is only detected by the smell, but in the cases now to be noticed the liquid is not so volatile, and its emission is itself one of the most objectionable features of the insect, even when the scent is not decidedly disagreeable. The various species of ladybirds are well known to emit from their mouth and other parts of the body a yellow, oily, acrid liquid, which has a very strong and disagreeable smell. This habit is paralleled, and in some cases exceeded, by members of the Chrysomelidæ, or golden apple beetles. The most noteworthy offender in this group is a shining metallic blue beetle with red wing covers, called Lina populi. Its larva, which feeds on poplar leaves, has two conical warts on the fore part of its body, and two rows of smaller tubercles on the back and down the sides, and from all these warts, as well as from the mouth and the joints of the legs, a horribly fetid, whitish fluid exudes when the creature is alarmed. Notwithstanding the disgusting nature of these secretions, or rather, perhaps, we should say because of this quality, they were formerly considered to have valuable medicinal properties, and are said to have been used as a specific against toothache.

Closely allied to the golden apple beetles, and indeed belonging to the same family, is the well-known "bloody-nose beetle" (Timarcha tenebricosa), which is a very common insect on wayside banks in limestone districts. It is a large and heavy, slow moving, very convex, black creature, faintly tinged with blue, with broad feet, which are of great service to it as it slowly crawls over the herbage. Its popular name arises from its disagreeable habit of exuding from its mouth and from the joints of its limbs a clear red liquid, which reminds one somewhat of the color of the blood of a vertebrate. Here, again, one can only imagine a protective function in this liquid. The appearance is the most objectionable feature of this secretion, there being no very strong smell attached to it. But such is not the case with the predaceous ground beetles, or Carabidæ, all of which pour out a fetid black or brown liquid from the moth when handled. A similar habit is exhibited by many carrion feeders, and in this case, as might be expected from the nature of the food, the liquid is still more foul.

The evil odor of scavanger beetles, however, does not always proceed from the mouth. Among the rove beetles there are many species that have a most repulsive odor, and in their cases the glands are often situated at the tail. The largest species of the group, Ocypus olens, the "devil's coach horse," may be taken as an example. It is a long dull black creature, shaped something like a gigantic earwig, attaining a length of upward of an inch. It is extremely active and remarkably courageous and aggressive. It may often be seen running about at the foot of brick walls, or by the side of pathways, where it is provided with subterranean cavities for retreat if necessary. But it is always prepared to show fight to any object, however large, and if interfered with, at once faces the intruder, and cocking up its tail, and raising its head, glares open-jawed defiance at its opponent with an aspect of the utmost ferocity. At the same time two milk-white vesicles make their appearance at the tail, standing out in bold relief on the dead black background of the body. A very disagreeable odor proceeding from these vesicles is soon perceptible, and makes one still less inclined than before to press one's attentions on so formidable a being.

The larger water beetles, again, emit an extremely fetid fluid when handled, but of the whole tribe, none perhaps is so repulsive as the little shining whirligig beetles (Gyrinidæ), whose mazy gyrations on the surface of still water must be familiar to every one. These little, highly polished creatures have the power of exuding an oily milk-white liquid from various parts of their bodies, which spreading over their shiny black surface, gives them the appearance of having been dipped in milk. So acrid is this liquid that the beetles must be an extremely undesirable article of diet, and as they spend their life at the junction of two transparent media, air and water, each of which is inhabited by predaceous and insectivorous beings, their villainous secretion no doubt serves them in good stead against both sub-aquatic and aerial foes, as well as possibly improving their means of flotation.

One of the most remarkable of the numerous secretions formed by beetles is that of the bombardier (Brachinus crepitans). This is a small beetle with red head, thorax, and legs, and bluish gray wing covers. Itself predaceous, it is nevertheless hunted by larger species which desire to prey upon it, and as speed and agility are unavailable against its larger and more active pursuers, it has developed a sort of battery of stern chase guns, by the aid of which it can effect a Parthian retreat, and bring about the discomfiture of its foes. When attacked it elevates its tail, and discharges therefrom toward its assailant a small quantity of a liquid which instantly vaporizes with a slight explosion, and forms a bluish white cloud. The expulsion of the liquid appears to require a certain amount of force, and so volatile is it, that if the insect be killed by plunging it into boiling water, the heat volatilizes the liquid while it is still within the abdomen, and causes the latter to swell out to a considerable size. This insect is to be found not unfrequently in the south of England, under stones, by the banks of streams, etc. Its secretion is a strong acid, which acts as an irritant when applied to the skin.—Knowledge.

SEEKING for a higher meteorological station among the mountains of Peru than that of Mount Chauchani, Professor Bailey of the Harvard College Observatory has established a station upon the top of the volcano El Misti, at an elevation of 19,200 feet.

ON ACQUIRED FACIAL EXPRESSION.

By LOUIS ROBINSON.

ALTHOUGH from infancy upward we are all, whether we know it or not, close students of physiognomy, and although a number of books, the result of much careful research, have been published upon the scientific aspect of the subject, there are certain facts connected with facial expression which, though often remarked upon, have never received explanation. With two of these—both of which bear upon the causes of acquired expression of a more or less permanent character—I propose briefly to deal in this article. I refer to the similarity of visage displayed by nearly all members of certain trades and professions; and to the likeness which often becomes apparent on the faces of people (generally married couples) who live together.

In addition to the bony framework, there are three chief anatomical factors which go to make up the expression of the face. These are the skin, the subcutaneous cushion of fat which contains the numerous blood vessels, and, lastly, the facial muscles. The nerve supply is abundant and peculiar. The integument receives sensory branches from the fifth cranial nerve, the blood vessels are under the control of the sympathetic system, and the muscles which have to do with expression receive motor impulses from the brain via the seventh cranial or facial nerve, first accurately described by Sir Charles Bell. It is to these numerous slips of muscular tissue, with their controlling telegraphic nerve fibers, that I wish especially to direct attention.

It is, of course, obvious to all who have an elementary knowledge of physiology that any movement of any part of the face is owing to the contraction of certain muscles, and that every such contraction must take place at the command of an impulse conveyed to the muscles by means of the motor nerves.

Into the historical evolutionary explanation of these movements it is not my intention here to enter. Let it suffice to say that there can be little doubt that they one and all represent some adaptation of the bodily structures to certain physical needs (possibly long obsolete) which accompanied the emotions of which the movements are now an index; just as the wagging of a dog's tail, which is now regarded as a mere sign of pleasurable excitement, was in the first place of vital importance as a signal to his comrades that game was afoot.

The connection between the muscles of expression and the emotional centers in the brain is of a most intimate character, and is largly independent of the will, although by strong volition any consequent movement of the features may generally be prevented. That the association is instinctive, and not acquired through individual or racial education, is shown by the fact that the facial changes which accompany the sentiments of fear, hatred, contempt, merriment, or mockery are practically identical the world over.

The extreme rarity of the man who can always keep his countenance, even when his will is fully awake, is as complete a proof of this intimate and automatic bond between the mental apparatus and the facial muscles as need be brought forward. Are we not all aware of exercising a restraining effort upon our features when we endeavor to hide our emotions? And is not the common phrase, "he gave way to his feelings," a recognition of the fact that the invariable instinctive tendency is, when the emotions are stirred, to yield to those outward manifestations which are obvious to the eye of another, and which are the results of motor nervous impulse?

Now, this fact is most important in the study of what may be called "static physiognomy," which treats of the interpretation of habitual expression when the countenance is at rest. It shows that in all probability every emotion, however slight, sends an impulse to the appropriate muscles, although the immediate nervous provocation may be much too faint to produce any marked movement. That such trivial and evanescent nerve impulses, although their effect may be at the time unfelt by the subject himself and imperceptible to lookers-on, may be, if often repeated, efficient factors in the formation of a habitual cast of countenance, I shall presently show.

It is plain that such efforts will become more perceptible when the first rotundity of youth has disappeared. We naturally look at a young face for a prophecy and at an old one for a record. But the materials from which we attempt to inform ourselves are of a very different character in the two classes. In the one case we see a general arrangement of features, which, according to some utterly inscrutable law, accompanies certain traits of mental and moral character. No satisfactory theory has ever been put forward to account for such facts as that human beings with a certain inherited squareness of jaw are always of a tenacious disposition.

But when we scrutinize an older face, we peruse the linear inscriptions upon its surface as we read a book of which we know the author. Not only do such and such conformations of its lines have a definite meaning, but we can form an opinion as to why and when (if not how) they were written. The caligraphy, of course, is not uniform in all cases, and there are various complexities about it which may render an exact interpretation a matter of difficulty. Trouble or passion, which in one instance is recorded in bold characters, in another may leave scarcely a visible mark; and it is obvious that a lean face will betray the story of emotional experience more readily than one covered with a mask of fat and smooth skin.

If we look at an anatomical representation of the human face with its integument removed, we see at once that the various groups of muscles are generally so arranged as to balance one another. Thus there is one set of muscles for opening the eyes or the lips, and another set for closing them; one group raises and another depresses the angles of the mouth, and so on. All these muscles, even when the features are quiescent, maintain a certain tone; for it is found that if one part of the face is paralyzed, the sound muscles near it draw it toward them and retain it there even when they are at rest. If one of the muscles or groups is stronger in proportion than its opponents, it will cause a marked change of expression, as is plainly seen in partial paralysis. It is a familiar fact that all muscles become larger and stronger through exercise; but the reason why they so increase is not such a simple matter. The

vitality of muscular, and indeed of all other living tissue, is strangely under the influence of the nervous system. If the nerves which supply a limb are totally destroyed, it shrinks with extraordinary rapidity; although the main blood supply remains perfect. At the same time a limb may be paralyzed as to motion and yet undergo but little wasting, because certain nerve fibers (called trophic because they have to do with nutrition) are left intact. In bedridden patients, again, in spite of a total want of exercise, the muscles often do not shrink in any great degree. Hence we see that nervous currents or impulses may influence the growth of a muscle apart from actual exercise.

Let us take an instance, the too visible results of which every one is familiar with. Persons who squint (with certain exceptions I need not here specify) are always "far sighted"—that is, the convex lens of that marvelous living camera, the eye, is not quite convex enough; and in consequence its focus is too long to permit rays from a near object to form a clear image on the retina. If the retina could be pushed back away from the lens, the difficulty would be overcome; but we cannot, as in the case of an opera glass or a photographic apparatus, lengthen the space between the lens and the spot upon which the image is to be projected to any great extent, so Nature has provided a focusing apparatus in the crystalline lens itself. By a muscular effort the elastic lens can be made more convex, and in this way the focus is shortened to the required length. In long-sighted or flat-lensed persons this is constantly being done when they are reading or looking at some near object.

Now, it so happens that one of the little muscles which move the eyeball—i. e., the internal rectus, which rolls the eye inward toward the nose—gets its nerve supply partly from the same source as do the muscles for shortening the focus of the lens. The latter, in far-sighted persons, are constantly being urged to action by impulses proceeding from the brain along the nerve, and part of the impulse invariably finds its way, owing to the intimate relation of the parts, to the internal rectus muscle. This muscle does not at first respond to the stimulus sufficiently to turn the eye inward every time the lens is accommodated for near objects; but the result of this nervous stimulation is in the long run the same as if the internal rectus were constantly called into action by a deliberate exercise of the will. It greatly increases in bulk and strength, and outpulls its opponent on the outer side of the eye (which gets its nerve supply from a different source), and so the balance of power is destroyed and a hideous inward squint is produced.

From this we can understand the effect of a long-continued dominant emotion on the face, even although it may exist in an individual too well bred to allow his countenance to be easily distorted by the prevailing passion. Whenever the thoughts take their habitual direction, a stream of nervous influence from the brain to the hidden expression muscles is the inevitable concomitant. The closest observer may not notice the least change of outline or the vaguest tremor of movement at the time, and the subject himself may be unwarned as to what is going on. Yet in the course of years the muscles so stimulated assert themselves over the others, and a permanent expression in accordance with the mental character comes out.

Close observation of almost any face under favorable circumstances supports this view. While engaged in studying the phenomena of sleep, I have repeatedly noticed that the apparent placidity of the features during slumber is deceptive. Even in dreams each fleeting emotion affects the facial muscles in some degree, and the apparent calm on the surface covers many little eddies and currents beneath, as one or other of them is thus provoked into partial activity. When the thoughts are all-absorbing and the owner of the face is off his guard, it does not require a very acute observer to see how the expression follows what is in the mind.

The other day, while traveling by train, I witnessed the parting of a pair of lovers. The damsel got into the carriage where we were seated, and until the train started there was an eloquent interchange of glances and smiles. As we steamed off, the last smile of parting gradually faded on the lassie's face. She shut her eyes and leaned back, so that she did not see that she was under observation, and at the same time the light showed her countenance with great distinctness. For the space of some twenty minutes, during which I was her fellow-passenger, the dimples of that parting smile would ever and anon appear, but in so slight a degree that, unless the opportunities for observation had been exceptional, they would not have been noticed. The movements of the muscles were so subtile that it was absolutely impossible to analyze them, or even to discern them severally. They were

". . . like the borealis race,
That flit ere you can point their place."

Yet one could gauge from moment to moment the depth, and to some extent the nature, of her thoughts of her lover.

Let me strongly recommend all physiognomists who travel by rail not to spend their time in the perusal of text books, while they have before them a row of living documents inscribed all over with the very aphorisms of the art. The opportunities for observation afforded by the British traveling hutch are such as to make one forgive its manifold inconveniences. Take the instance of the old lady who is perturbed about the safety of her ticket and her luggage. Her totality of expression has a heavy groundwork of care, upon which start and flicker endless additional lines, as this or that possibility of trouble crosses her mind. It requires some self-restraint on the part of the enthusiastic student to refrain from making such a one the subject of physiognomical research by hinting various moving hypotheses concerning the perils of the journey or the fate of her numerous packages. Let him not forget, however, that although such experiments are not forbidden by the Vivisection Act, the methods of Parrhasius are out of harmony with the spirit of the nineteenth Christian century.

The incessant flow of involuntary nerve currents to the facial muscles doubtless accounts for the odd similarity of expression among men of the same vocation. In many such cases the conditions are so complex that it seems impossible to lay one's finger upon the special items of environment which conduce to the facial characteristics exhibited by nearly all members of certain trades and professions. What, for instance, is there about the process of making shoes which evokes the unmistakable cobbler's visage? The portrait of Edward, the Banff naturalist, in Mr. Smiles' book, shows the type in a marked degree. As far as my own observation carries me, the cause must be looked for in the last, lapstone, and wax end of old fashioned cordwainery; since men who work the machines in modern boot factories, or who do ordinary repairing, do not exhibit the expression. It appears probable that the tailor's distinctive type of face may have been partially created by his habit of working his jaws concomitantly with his shears. Let any one watch a person cutting a piece of tough material with scissors, and he will see that the lower part of the face wags in rhythmic and spontaneous unison with the blades. Shepherds and farm laborers who join sheep shearing gangs certainly acquire a different expression while engaged in this kind of work. The cast of countenance by which one so easily recognizes a groom is partially explicable from the fact that the muscles which close the jaw and compress the lips are always called into play when we are asserting our will over that of a horse. Nearly all jockeys and other horsey men have a peculiar set of the mouth and chin, but I have been unable to distinguish any special characteristic about the eye or upper part of the face. It is instructive to compare the visage of the ruler of horses with that of the ruler of men. The horseman's face shows command in the mouth, the drill sergeant's in the mouth and the eye. The last is undoubtedly the most effective instrument in exacting obedience from our own species. Here we get a hint of the cause of that want of dignity, that element of coarseness, which is discernible in the countenances of some men and women who have much to do with horses. The higher and noble method of expressing authority is outweighed by the lower and more animal one.

Generally speaking, it is a strenuous contest with minor difficulties which produces a thin and rigid set of lips. It is seen almost invariably in housewives of the Martha type, who are "careful and troubled about many things," and whose souls are shaken to the center by petty worries within doors, and strife a outrance with shortcomings of the scullery maid or the cook.

The compressed lip so loved (and so often misinterpreted) by novelists is a sign of weakness rather than strength. It tells of perpetual conflicts in which the reserves are called into the fray. The strong will is not agitated into strenuous action by the small worries of the hour, and the great occasions which call for its whole forces are too few to produce a permanent impress of this kind upon the features. The commanding officer, assured of his men's obedience, does not habitually keep his lip muscles in a state of tension. Look at the sea captain, the most absolute monarch on earth. He carries authority and power in his face, but it resides in his eye and the confident assurance of his easily set mouth. Every spar and shaft and muscle in his floating realm must obey him, and he knows it. This is probably a reason why the sea captain's and the engine driver's show a certain similarity of type. The engine driver can make his captive giant, strong as ten thousand men, obey the pressure of his finger. His lips are usually calm, like those of the statues of the wielder of thunderbolts on Olympus. Who ever saw a man commanding a man-of-war or driving a locomotive with the contentious lip of a school usher?

The typical expressions of the members of those three liberal professions which Sir Thomas Browne says are all founded upon the fall of Adam are well enough recognized to have been long the prey of the caricaturist. The several distinctive traits of each, and the possible causes which give rise to them, are too complex to be dealt with in a single article. Speaking very generally, the cleric's face is indicative of authority (of the thin-lipped kind) and of a dignified sense of the sanctity of his office. The doctor's jaw and mouth are less rigid, yet tell of decision. His eye is vigilant and sympathetic, and his whole facial aspect conveys the idea of a fund of untapped wisdom. The lawyer's countenance is confident and confidential, with a pouncing alertness of the eye, and a prevailing expression of weighty perspicacity.

Of course it must be understood that in such a summary one is dealing with the broadest generalities. Marked exceptions to the rule for each class will be within every one's experience. I am inclined to think that in the learned professions the facial characteristics are much less marked than formerly. This may partly be accounted for by the modern laxity of fashion as to shaving the lip and chin. But also, there can be little doubt that the custom of carry a sort of perpetual personal trade mark is diminishing. Military officers no longer wear their uniform in private life, and the doctor and lawyer have both acquired a weakness to be classed, socially, as human beings.

It is noteworthy (and here my own observation has been supported by one of the most alert minds of this generation) that the leading members of the medical and legal professions do not display the facial symbols to anything like the same extent as the rank and file. This is especially so with regard to the expression of the mouth, and may be due to the absence of that anxious endeavor to look like a wise doctor or lawyer which possesses most ordinary practitioners in their earlier years.

The fact that two people who live long together tend to grow alike is accounted for by unconscious mimicry reacting upon the muscles of expression in the same way that a ruling passion does. This tendency to facial imitation is very general—in fact, almost universal—and may be so marked as to be easily noticed; so that, when two people are engaged in animated conversation, the expression of the listener may often be seen to echo that of the speaker. How "infectious" is a smile or a laugh, even when the idea which gave rise to it in the first case is not transferred!

Several times, when talking to young people, I have suddenly and purposely adopted some change of expression, such as the raising of the eyebrows; and this, although not the least apropos to the words spoken at the time, has instantly evoked a like movement on the faces before me. The response was quite involuntary, and was a pure piece of instinctive reflex action. Why does a yawn spread like pestilence through the room when conversation flags? I know of those who have started such an epidemic by a little piece of acting, and not a mouth in the company (save the guilty one) knew why it gaped. Have not we all noticed that a man of marked individuality becomes a center of physical influence to those who wait on his words, so that his gestures, tones of voice, and turns of phrase are reproduced? I know a tutor whose peculiarities of speech and carriage have been adopted more or less by every one of his pupils during the last six years, and several of them have come to resemble him in feature. This unconscious imitation of expression is very noticeable in children.

For some reason which we cannot fathom, the imitative faculty is so ingrained in us that what the eye perceives the brain makes haste to reproduce without stopping to ask our permission; and where two people live long together the facial muscles of each are constantly receiving stimuli prompting them to mimicry. As in the case of the emotions, these influences may be infinitesimal at any given moment, and may give rise to no visible change of expression. Yet in the course of time they tend to mould the whole countenance, feature for feature, into an almost exact facsimile of another.—Blackwood's Magazine.

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